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A Consolidation of Engineering News, Engineering Record The Sanitary Engineer, and The Contractor

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Contents for February 23, 1933

VOLUME 110, NUMBER 8

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Published every Thursday. Price 25c. per copy. Subscription, domestic, Central and South America, $5 per year. Canada, including duty, $7.50. Foreign $9 or 45 shillings. Entered as second-class matter April 11, 1917, at the Post Office at New York, N. Y., under the Act of March 3, 1879. Printed in U. S. A. Cable Address "MCGRAWHILL, New York." Member A.B.P. Member A.B.C.

McGRAW-HILL PUBLISHING COMPANY, INC., 330 WEST 42D STREET, NEW YORK, N. Y.

Editorial and Publishing Offices: 330 West 42d St., New York; 520 North Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, London, W. C. 2, England. Branch Offices: Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Greenville, S. C.; Los Angeles. James H. McGraw, Chairman of the Board; Malcolm Muir, President; James H. McGraw, Jr., Vice-President and Treasurer; Mason Britton, Vice-President; Edgar Kobak, Vice-President; H. C. Parmelee, Vice-President and Editorial Director; Harold W. McGraw, Vice-President; C. H. Thompson, Secretary.

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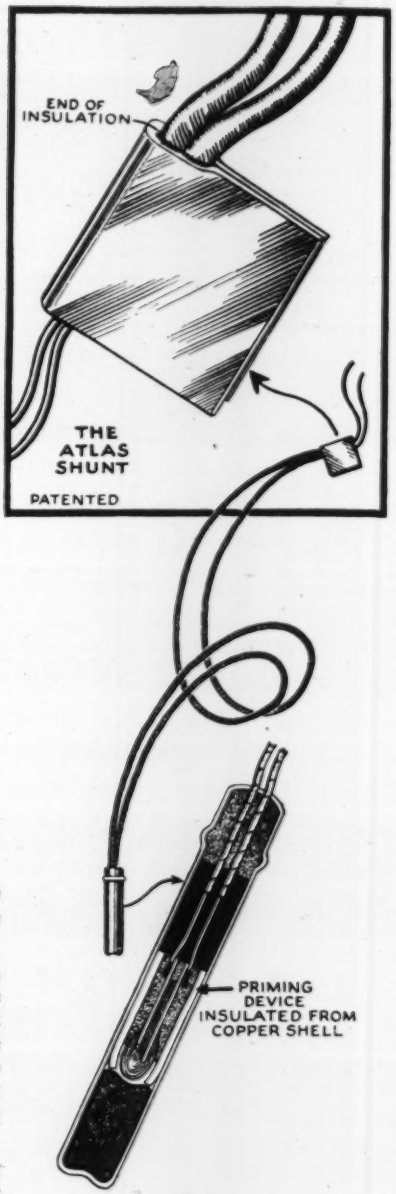

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Vancouver's New Harbor Crossing

Burrard Bridge connects residential and business districts—Approach contains Canada's longest concrete girders—Location near city park and proposed civic center influences architectural treatment

By J. R. Grant

Consulting Engineer, Vancouver, B. C.

CONNECTING the principal business and residential sections of Vancouver and crossing the entrance of False Creek, which is the city's secondary harbor, the Burrard Bridge provides an important link in the boulevard system of that city. With a total length of 2,317 ft., the bridge has long reinforced-concrete viaducts and a symmetrical central section consisting of four steel deck-truss spans and a main channel span of 294 ft. Provisions were made for a future lower railroad deck that would be provided with a swing span in the channel. The location is prominent from the harbor and from the city, is closely associated with the municipal park system and adjoins the location for the proposed civic center. For these reasons the design of the structure was modified, with a tendency toward a monumental type, and architectural treatment was an important consideration.

Viaduct Approaches — The concrete viaduct approaches, with a combined length of 1,647 ft., provide a 60-ft. roadway and two 8½-ft. sidewalks supported by three lines of longitudinal girders 27 ft. c. to c. and secondary beams at the ends of the cantilever brackets. The usual system of cross-beams and concrete slab completes the deck structure. Supports consist of concrete column bents, except where the south viaduct crosses extensive tracks and shops of the B.C. Electric Railway, where column spacing was modified as necessary.

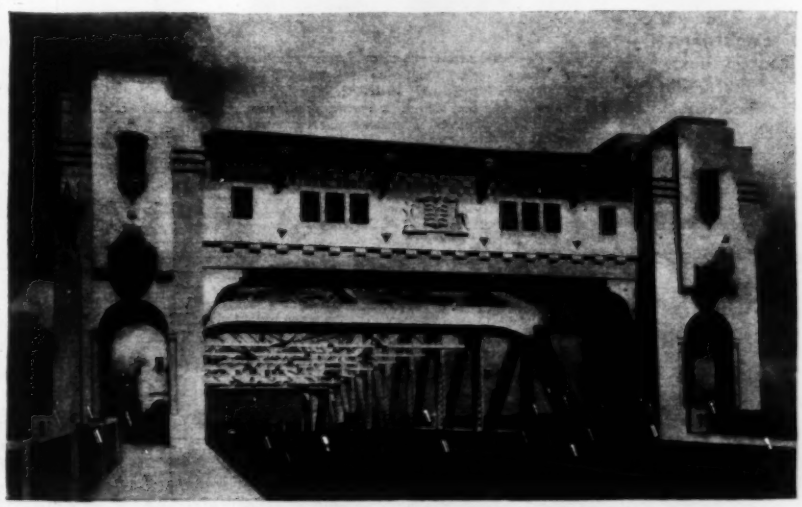


Fig. 1—Architectural pylons were provided because the site is conspicuous and near the location of the proposed civic center.

The maximum girder span in this approach system is 89 ft. c. to c. of columns, which is considered to be the longest reinforced-concrete girder span in Canada. This span is the center of a three-span unit with 76 ft. 9-in. end members. The girders are 29 in. wide, and the one along the center line is 7 ft. 3 in. deep at mid-span and 12 ft. 4 in. over the columns, with curved haunches reaching to the quarter points. Reinforcing of the center-line girder (Fig. 2) consists of 27 1½-in. round bars in the end spans and 23 similar bars in the center. The curb girders are 3 in. shallower. Where girders are continuous over columns they are fixed with vertical steel. The free ends of girders are supported by pin or rocker bearings; the latter are contained in reservoirs packed with grease.

Timber falsework was used for the viaduct

construction, and concreting of the deck and upper sections of the bents was carried on with a timber tower 158 ft. high mounted on heavy timber skids. The tower was moved along a plank roadway as the work progressed.

Main Pier Foundations—The main piers on either side of the navigation channel are founded on sandstone about 43 ft. below mean-high-water elevation. Foundations are 42 by 102 ft., and excavating was done by a dipper dredge; some shooting was required to loosen the sandstone in preparing the sites. Timber cribs with steel cross-bracing were then anchored in position, filled and sunk. The foundation areas were cleaned and the concrete seals placed by tremie.

A timber frame 26 ft. high was built over the crib to support two 10-ft.-square hoppers and eight 10-in. tremies, each hung by cable attached to the drums of four hoists on the crib platform. Concrete was supplied from two 1-yd. paving maxers at the site and from a central mixing plant. By the aid of a hoisting tower the concrete was distributed by chute to the hoppers. Secondary chutes from each hopper led to the four tremies. The 2,900 cu.yd. of concrete required for the seal of the south pier was poured in 28 hours of continuous operation, and the 3,400 yd. in the other main pier in 47 hours.

Above the footing each pier is 96x33 ft. in section, with a 3½-ft. projection on the channel side for the support of the future railway swing span. Above this elevation the piers have a slight batter and consist of two towers connected above the required railway clearance by a 24-in. cross-wall. The towers are hollow, with deep wells extending from the deck to the pier footing. Total concrete in the two piers is about 23,500 yd. Creosoted timber fenders protect the channel side of each pier from navigation and particularly against booms of logs.

Steel Truss Spans—The main channel span is 294 ft. 2 in. between centers of bearings. The trusses are of Pratt type with curved upper chords, and are spaced 65 ft. apart. To avoid excessive bending in the vertical truss members due to deflection of the long floor beams, the end connections were set and milled for vertical reaction under full dead load.

On either side of the main span is a 216-ft. 8-in. Warren deck truss flanked by 176-ft. similar truss spans. These trusses are 30 ft. deep and are spaced 43 ft. apart, with the floor beams supported on top of the chords and cantilevered out to support the 80-ft. total width of deck.

Rockers of 6-in. diameter, immersed in oil, are used for all truss expansion bearings. A depth of 7 in. of oil is specified to insure complete immersion of the tops of rockers and to avoid excessive condensation of water vapor within the reservoir. The end plates are fastened with tap bolts to the masonry plates, which have sufficient length to permit movement of the sole plates inside the oil reservoirs.

The five steel spans were erected on falsework from the south end of the structure by a 28-ton traveler mounted on 20x24-in. fir skids 60 ft. long. To provide for navigation during erection, a vertical and horizontal clearance of 90 ft. was required, which necessitated the cantilever erection of the four north panels of the channel span.

The pylons over the channel piers are 48 ft. high above the deck, or 146 ft. above high-water elevation. They are 16x24 ft. in section, with barrelled and cross-vaulted ceilings over the sidewalks. Architectural treatment is shown in Fig. 1. Cross-galleries are provided above the roadway supported on hollow reinforced-concrete girders. Over each sidewalk entrance is the precast concrete prow of a boat mounting the busts of Captain Vancouver and Captain Burrard. Floodlights for the pylons are provided.

The fill for the railway embankment under the south approach extends a

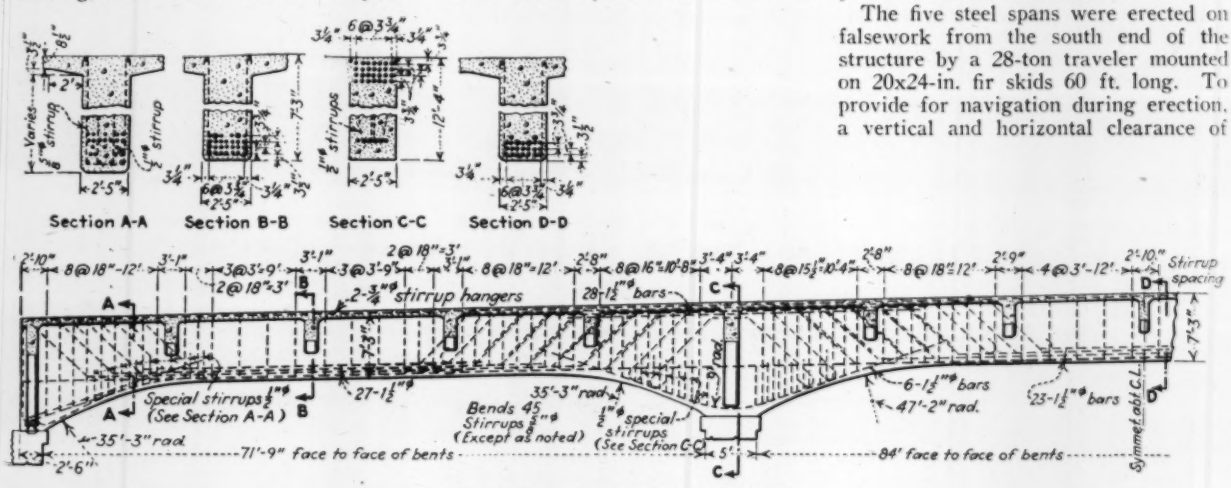


Fig. 2—Details of concrete girders in the approach viaduct to the Burrard Bridge, Vancouver, B C.

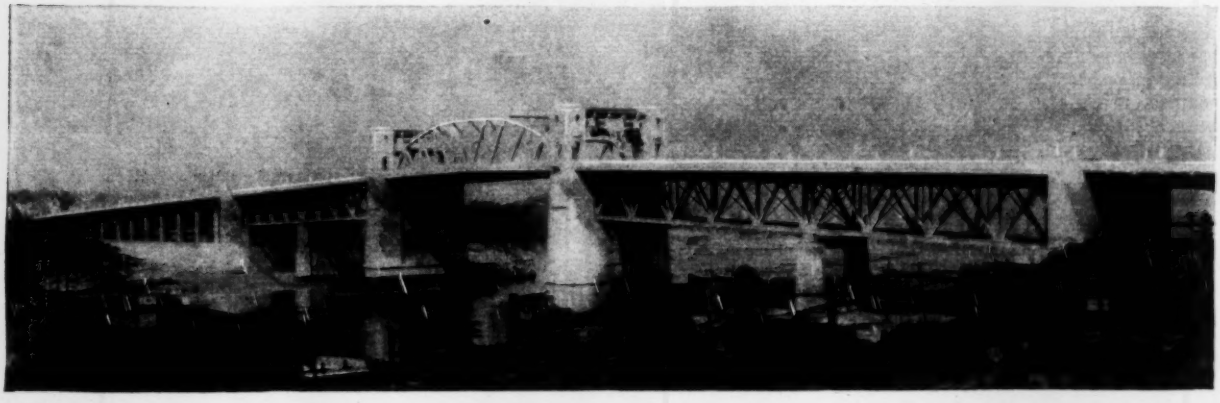


Fig. 3—Burrard Bridge is an important link in Vancouver's boulevard system. Note provisions for future railroad crossing at lower level, for which a swing span over the channel is contemplated.

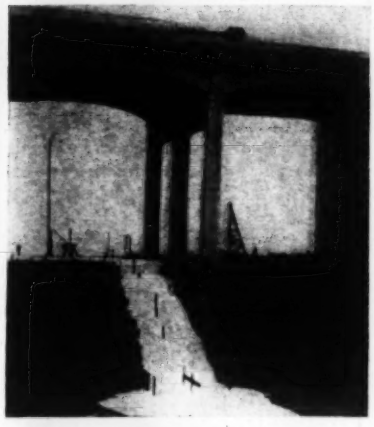


Fig. 4—Fill for the future railroad level under the south approach was placed hydraulically behind timber bulkheads.

distance of 700 ft., with a top width of 62 ft., side slopes of 1½:1 and a maximum depth of 30 ft. The material, consisting of sand, gravel and some clay, was pumped by a 21-in. hydraulic dredge that placed a maximum of 6,000 cu.yd. in 24 hours. The bulkhead required and the overflow from the hyraulic operations are shown in Fig. 4.

At the south approach it is necessary to provide for cross-street traffic, and three islands are used to effect the separation of traffic lines (Fig. 5). Four lanes are provided in each direction, with the width on curves increased to 11¼ ft. The lanes are marked by longitudinal through and dummy joints in the 9-in. concrete paving. Through transverse joints are at 90-ft. intervals, with intermediate dummy joints at 15-ft. spacing. Automatic traffic lights provide for control at this intersection.

Costs and contracts

The total cost, exclusive of work done directly by the city and land damages, was $1,844,932. The general contract was held by the combined firms of Hodgson, King & Marble and Dawson, Wade & Co., Ltd.

Fig. 5—Broad sweeping approach, with islands to help direct traffic, is a feature of the Burrard Bridge.

Structural steel was fabricated at the local plants of the Dominion Bridge Co., Ltd., and the Western Bridge Co., Ltd., who were also subcontractors for erection of steel.

C. Brackenridge is city engineer, and Sharpe & Thompson were collaborating architects. The writer was consulting engineer, and A. J. Leamy was his resident engineer.

Record Cement-Pumping Lift Used at Pine Canyon Dam

Bulk cement trucked to site is pumped up to mixing plant 302 ft. above

A RECORD installation for pumping bulk cement, as shown by the drawing below, will lift bulk cement at the Pine Canyon Dam from the silo at the end of the truck haul 302 ft. to the mixing plant above the site. This vertical lift is double that of any previous similar installation. The rate of delivery is 150 bbl. per hour; the cement supplies two 4-yd. mixers.

The 245-ft. concrete dam is being built by Pasadena, Calif., to provide a storage reservoir on the San Gabriel River. Bulk cement is trucked directly from the mills in special truck and trailer units carrying a 21-ton combined load.

The contents of trailers and trucks are dumped directly into a hopper and lifted into a 4,000-bbl. steel silo that is used for storage. The silo is located on the highway below the dam and across the river from the plant, which is situated high on the left abutment above the site. Cement is withdrawn from the silo into the cement pump and discharged through a 5-in. line 730 ft. long across the river and up 302 ft. to the cement bin at the mixing plant. A two-way valve is provided near the discharge end so that the excess above the use of the mixing plant is delivered into another steel storage silo near the plant. This arrangement reduces rehandling to a minimum.

The installation is part of the construction plant of Bent Bros., Inc., Winston Bros. Co. and W. C. Crowell, joint holders of the contract for the construction of the Pine Canyon Dam. S. B. Morris is chief engineer and general manager of the water department. The cement pumping installation was designed and installed by the Fuller Co.

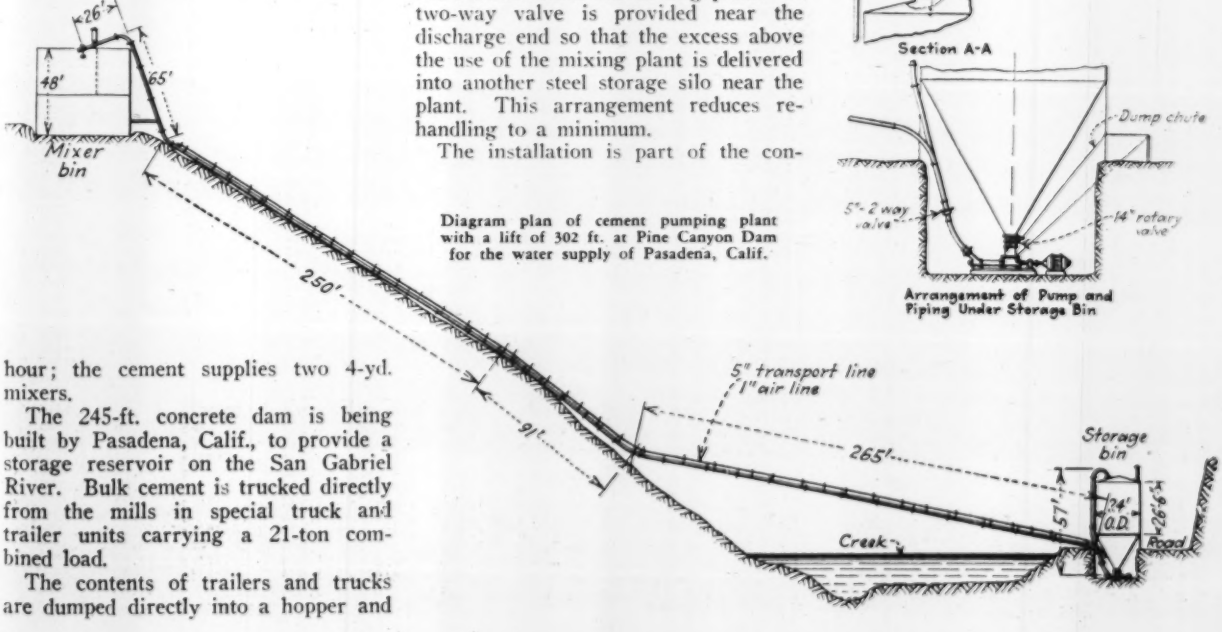
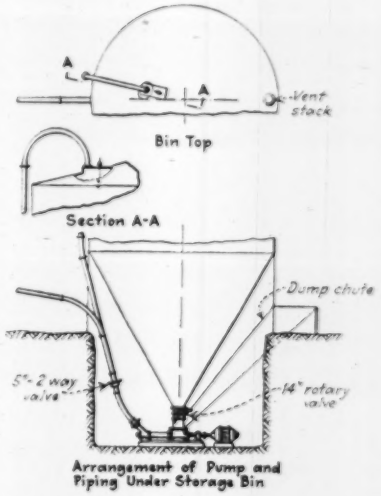


Diagram plan of cement pumping plant with a lift of 302 ft. at Pine Canyon Dam for the water supply of Pasadena, Calif.



Arrangement of Pump and Piping Under Storage Bin

Determining Stresses in Semi-Elliptical Sewers

Analysis of the arch ring under trench conditions of loading is facilitated by tabular method of computation

By C. D. Williams
Bridge Dept., New York Central R.R. West. Cleveland, Ohio

IN THE Feb. 13, 1930, issue of *Engineering News-Record* there appeared an article entitled "Stress Formulas for Semi-Elliptical Sewer," by Herman Dresser. The article described the problem of stress determination as applied to trench condition of loading on the Metcalf and Eddy standard section, and the formulas presented for moment, thrust and shear are applicable to that section only. It is believed that many engineers will be interested in a method that is applicable to other sections as well, and to other conditions of loading. The following method is applicable to any form of ring or condition of loading that is symmetrical about the vertical axis. It does not require a large amount of work and does not involve any difficult mathematics.

In order to compare results of this method with the formulas presented in the earlier article, a section has been chosen that agrees with the Metcalf and Eddy standard section, taking $D = 10$ ft. The total load P per linear foot of trench is assumed to be carried by six voussoirs at the crown and is distributed to them in proportion to the horizontal projection of the extrados.

Due to symmetry of loading and section there is zero shear at points A and B, the tangents to the elastic curve at points A and B remain hozizontal after load, and there is zero horizontal movement of points A and B. Then the only forces acting on the half arch ring are the external loads, end moments of unknown magnitude, called M_A and M_B, and reactions at A and B (see Fig. 2). As soon as the magnitude of these end moments is known, the moment, thrust and shear at any point are determinate.

Since the tangent to the elastic curve at point B is unchanged in direction, relative to the tangent at point A, $\int_B^A \frac{M}{EI}\,ds = 0$; and since the deflection of point B with reference to point A is zero (in direction of y-ordinates), $\int_B^A \frac{Mx}{EI}\,ds = 0$. These two equations are sufficient to solve for the two unknown values M_A and M_B. Modulus of elasticity being constant and moment of inertia being assumed

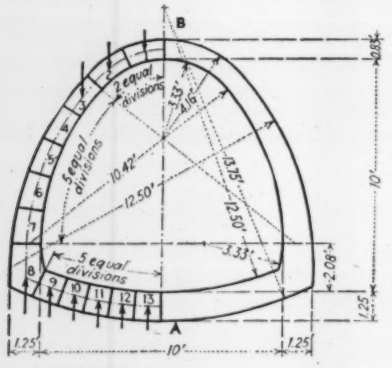


Fig. 1—Ten-foot semi-elliptical sewer, Metcalf and Eddy standard section, divided into thirteen voussoirs for purposes of analysis.

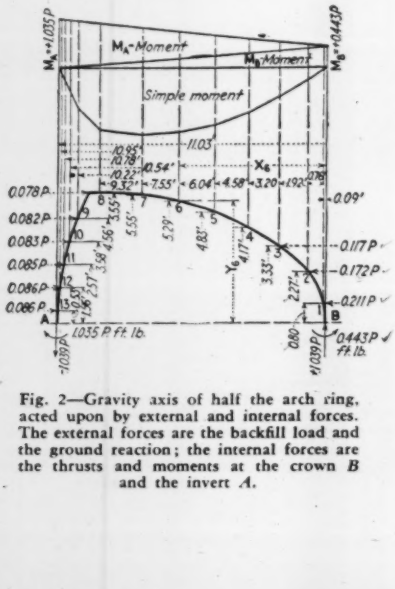


Fig. 2—Gravity axis of half the arch ring, acted upon by external and internal forces. The external forces are the backfill load and the ground reaction; the internal forces are the thrusts and moments at the crown B and the invert A.

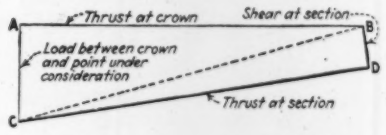


Fig. 3—Force diagram for determining thrust and shear at any point along the arch. *AB* is thrust at crown; *AC* is sum of external loads from crown to point under consideration; *CD* is drawn parallel to tangent to arch ring and is equal to the thrust at that point; *BD* is perpendicular to *CD* and is equal to the shear at the point.

TABLE I — SIMPLE MOMENTS

Point	Moment	$I = D^3$	$\frac{M}{I}$	ds	$\frac{M}{I}ds$	x	$\frac{Mx}{I}ds$
1	+ .004P	.578	+ .0078P	1.623	+ .0126P	.09	+ .0011P
2	— .272P	.578	— .4715P	1.623	— .7665P	.76	— .5815P
3	— .620P	.616	—1.0100P	1.532	—1.5450P	1.92	— 2.9650P
4	— .975P	.722	—1.3490P	1.532	—2.0650P	3.20	— 6.6100P
5	—1.237P	.907	—1.3650P	1.532	—2.0850P	4.58	— 9.5500P
6	—1.393P	1.158	—1.2030P	1.532	—1.8450P	6.04	—11.1300P
7	—1.448P	1.541	— .9385P	1.532	—1.4350P	7.55	—10.8300P
8	—1.358P	2.651	— .5125P	1.966	—1.0075P	9.32	— 9.3950P
9	— .896P	1.953	— .4595P	1.034	— .4750P	10.22	— 4.8650P
10	— .546P	1.953	— .2805P	1.034	— .2895P	10.54	— 3.0650P
11	— .275P	1.953	— .1408P	1.034	— .1455P	10.78	— 1.5650P
12	— .093P	1.953	— .0474P	1.034	— .0491P	10.95	— .5385P
13	0	1.953	0	1.034	0	11.03	0
Σ					—11.6955P		—61.0939P

TABLE II — M_A MOMENTS

Point	Moment	$I = D^3$	$\frac{M}{I}$	ds	$\frac{M}{I}ds$	x	$\frac{Mx}{I}ds$
1	.0081M_A	.578	.0141M_A	1.623	.0229M_A	.09	.0021M_A
2	.0688M_A	.578	.1192M_A	1.623	.1935M_A	.76	.1468M_A
3	.1741M_A	.616	.2835M_A	1.532	.4335M_A	1.92	.8310M_A
4	.2895M_A	.722	.4010M_A	1.532	.6145M_A	3.20	1.9620M_A
5	.4145M_A	.907	.4575M_A	1.532	.7000M_A	4.58	3.2000M_A
6	.5475M_A	1.158	.4735M_A	1.532	.7245M_A	6.04	4.3800M_A
7	.6835M_A	1.541	.4435M_A	1.532	.6785M_A	7.55	5.1150M_A
8	.8440M_A	2.651	.3185M_A	1.966	.6265M_A	9.32	5.8350M_A
9	.9285M_A	1.953	.4745M_A	1.034	.4910M_A	10.22	5.0250M_A
10	.9530M_A	1.953	.4880M_A	1.034	.5045M_A	10.54	5.3250M_A
11	.9750M_A	1.953	.5000M_A	1.034	.5165M_A	10.78	5.5550M_A
12	.9910M_A	1.953	.5075M_A	1.034	.5250M_A	10.95	5.7500M_A
13	1.0000M_A	1.953	.5115M_A	1.034	.5300M_A	11.03	5.8550M_A
Σ					6.5609M_A		48.9819M_A

TABLE III — M_B MOMENTS

Point	Moment	$I = D^3$	$\frac{M}{I}$	ds	$\frac{M}{I}ds$	x	$\frac{Mx}{I}ds$
1	.9919M_B	.578	1.7200M_B	1.623	2.7950M_B	.09	.2515M_B
2	.9312M_B	.578	1.6150M_B	1.623	2.6150M_B	.76	1.9900M_B
3	.8259M_B	.616	1.3400M_B	1.532	2.0550M_B	1.92	3.9400M_B
4	.7105M_B	.722	.9870M_B	1.532	1.5040M_B	3.20	4.8350M_B
5	.5855M_B	.907	.6480M_B	1.532	.9920M_B	4.58	4.5450M_B
6	.4525M_B	1.158	.3910M_B	1.532	.5980M_B	6.04	3.6100M_B
7	.3165M_B	1.541	.2055M_B	1.532	.3145M_B	7.55	2.3700M_B
8	.1560M_B	2.651	.0588M_B	1.966	.1155M_B	9.32	1.0390M_B
9	.0715M_B	1.953	.0366M_B	1.034	.0379M_B	10.22	.3880M_B
10	.0470M_B	1.953	.0241M_B	1.034	.0249M_B	10.54	.2625M_B
11	.0250M_B	1.953	.0128M_B	1.034	.0132M_B	10.78	.1421M_B
12	.0090M_B	1.953	.0046M_B	1.034	.0048M_B	10.95	.0522M_B
13	0	1.953	0	1.034	0	11.03	0
Σ					11.0698M_B		23.4253M_B

COMPUTATION OF SIMPLE MOMENTS

Moments about B

No. 13	$.086P \times +.53 =$	$+.0456P$
12	$.086P \times +1.56 =$	$+.1342P$
11	$.085P \times +2.57 =$	$+.2185P$
10	$.083P \times +3.58 =$	$+.2972P$
9	$.082P \times +4.56 =$	$+.3740P$
8	$.078P \times +5.55 =$	$+.4325P$
1	$.211P \times -0.80 =$	$-.1688P$
2	$.172P \times -2.27 =$	$-.3910P$
3	$.117P \times -3.33 =$	$-.3900P$
		$+.5522P$

Reaction at A

$-.5522P \div 11.03 = -.0502P$

Point No. 13, moment = 0

Point No. 12

$.050P \times .08 = .004P$
$.086P \times 1.03 = .089P$
$.093P$

Point No. 11

$.089P$
$.172P \times 1.01 = .174P$
$.050P \times .25 = .012P$
$.275P$

Point No. 10

$.262P$
$.257P \times 1.01 = .260P$
$.050P \times .49 = .024P$
$.546P$

Point No. 9

$.522P$
$.340P \times .98 = .333P$
$.050P \times .81 = .041P$
$.896P$

Point No. 8

$.855P$
$.422P \times .99 = .418P$
$.050P \times 1.71 = .085P$
$1.358P$

Point No. 7

$1.273P$
$.50P \times 0$
$.05P \times 3.48 = .175P$
$1.448P$

Point No. 6

$1.273P$
$.50P \times -.26 = -.130P$
$.05P \times 4.99 = .250P$
$1.393P$

Point No. 5

$1.143P$
$.50P \times -.46 = -.230P$
$.0502P \times 6.45 = .324P$
$1.237P$

Point No. 4

$.913P$
$.50P \times -.66 = -.330P$
$.0502P \times 7.83 = .392P$
$.975P$

Point No. 3

$.583P$
$.50P \times -.84 = -.420P$
$.0502P \times 9.11 = .457P$
$.620P$

Point No. 2

$.163P$
$.383P \times -1.06 = -.406P$
$.0502P \times 10.27 = .515P$
$.272P$

Point No. 1

$-.243P$
$.211P \times -1.47 = -.310P$
$.0502P \times 10.94 = .549P$
$-.004P$

to vary directly as the cube of the thickness of the ring at any point, the two equations may be written

$$\int_B^A \frac{M}{D^3}\,ds = 0, \text{ and } \int_B^A \frac{Mx}{D^3}\,ds = 0.$$

M is composed of three parts at any section, a proportional part $\frac{(x)}{L}$ of M_A, a proportional part $\frac{(L - x)}{L}$ of M_B and the simple moment of external loads which would be present with ends unrestrained.

When the half ring is laid out to large scale and the gravity axis divided into a convenient number of lengths, ds, the x and y ordinates for the center of each section and the lengh of each section may be scaled and entered in the proper columns of Tables I, II and III. The thickness at the center of each section is then scaled and the cube entered in the same tables. With loads acting on any section considered as concentrated at the center of its length, the simple moments are computed and entered in Table I, and are given a + sign when causing compression in the outer fibers. Proportional parts of the two end moments are then computed and entered in similar columns of Tables II and III. The remaining work of the tables is evident.

The equations now become, in this case,

$$\int_B^A \frac{M}{D^3}\,ds = 6.5609M_A + 11.0698M_B - 11.6955P = 0, \text{ and}$$

$$\int_B^A \frac{Mx}{D^3}\,ds = 48.9819M_A + 23.4253M_B - 61.0939P = 0, \text{ from which}$$

$M_B = +0.443P$ and $M_A = +1.035P$, indicating compression in the outer fibers of the ring at both A and B. These values check the values of $0.0444DP$ and $0.1039DP$ computed by Mr. Dresser in the previous article remarkably closely, considering that all computations were performed with a 6-in. slide rule.

The moment diagrams may now be drawn to scale as in Fig. 2, and the magnitude of the moment at any section may be found by taking the algebraic sum of the ordinates to the three diagrams at that point, or the values at any point may be computed from the proportional parts already known.

The thrusts at points A and B are found by combining the simple reactions at these points with the effect of end restraint. The simple reactions are found to be the moment of the external loads acting on the half ring of Fig. 2 about A or B, divided by the span length, or $+0.0502P$ at B and $-0.0502P$ at A. Then the thrust at $B = +0.0502P - \frac{0.443P}{11.03} + \frac{1.035P}{11.03} = +0.1039P$, or compression; and at $A = -0.0502P + \frac{0.443P}{11.03} - \frac{1.035P}{11.03} = -0.1039P$, or tension. With these thrusts known, the thrust and shear at any section may be found as suggested by Mr. Dresser, by graphic resolution, and repeated here to complete this analysis. In Fig. 3, lay off AB horizontally, equal to the thrust at point B $(.1039P)$; lay off vertically AC, equal to the loads between B and point to be computed and in the direction of these loads. Then BC will be the resultant force at the section. Lay off CD in the direction of the tangent to the curve at the point to be computed, and DB perpendicular to DC. DC will then be the thrust at the section and DB the shear, to scale.

When any ring is to be investigated for more than one condition of loading, Tables II and III need not be repeated, the simple moments being the only new quantities and requiring only the completion of a new Table I to obtain new values for the two equations.

For an investigation of the same sewer built on a rock foundation, as suggested by Case I of Mr. Dresser's article, the above method would be used except that only points 1 to 8 would be used and point A would be at the intersection of the vertical wall with the base of the sewer.

The vertical loading used in the above problem conforms to Bulletin 31 of the Engineering Experiment Station of Iowa State College and applies to sewers built in ditches. In the case of a sewer built in new fill the loading will consist of active horizontal earth pressures on the vertical projection of the ring in addition to the vertical earth loads. It is usually better to analyze the ring for vertical loading and horizontal loading, each as a separate operation, and combine the results. The weight of concrete in large structures is frequently an important stress factor and should be included with the vertical voussoir earth loads.

This method of analysis is considered to have the advantage that all conditions of loading may be computed and that the ring is still capable of analysis if increased or decreased in section at any points, with only the restriction that the ring and loading be symmetrical about the vertical axis. Any set of formulas, to be accurate, is necessarily applicable only to special cases.

High Stresses in Columns

From an analysis of tier-building frames under vertical load, Prof. R. R. Martel of the California Institute of Technology, Pasadena, finds that high bending stresses occur in the columns as a result of the end fixation of the girders. In a brief note in the September *Bulletin* of the Seismological Society of America he gives results of exact calculations for a frame of two unsymmetrical bays, four stories high. Under a live load of only 15 lb. per sq.ft. he found concrete stresses in the columns of 1,200 lb. per sq.in., though they were designed for 500 lb. per sq.in., the code stress. The column moments at the top of the story always were higher than that at the bottom, by as much as 30 per cent.

This latter effect, Professor Martel suggests, may serve to explain why a destructive earthquake usually does more damage near the top of the story than near the bottom. On the ground that column moments due to girder restraint are commonly ignored by designers, he concludes that his figures prove that they must be taken into account for safe and economical designing.

Bearing Power of Clay Is Determinable

Clay has a definite bearing capacity, and soil tests can be interpreted so as to make possible the design of substructures for known and limited amounts of settlement

By William S. Housel
Assistant Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich.

THAT a definite bearing value of clay does not exist is a statement which the practicing engineer must accept only after it has been supported by indisputable evidence in the form of carefully collected data. Although this statement has recently been given a prominent place in several published articles on soil mechanics, it is significant that no such supporting data accompany it.

The above conclusion almost completely ignores the results of numerous soil tests and a wealth of experience all indicating that heavy structures have been built on deposits of clay and other cohesive soils without progressive settlement. It also ignores the semi-elastic properties of cohesive soil, which are a matter of common knowledge and which have been demonstrated by ample experimental data. The disregard of soil test data cannot be justified by the belief expressed by some, that there are no known methods of expressing the relation between bearing capacity of soil and size of loaded area, and therefore no method by which soil tests may be correlated with the behavior of actual structures. Further than this the frequent statement that test results on comparatively small areas are not applicable to the larger bearing areas of actual structures deserves corroboration from much more substantial observations than have been presented up to the present time.

It is the purpose of this article to present data to show, first, that some clay does have a definite bearing capacity, and second, that soil tests can be interpreted in such a way as to make possible the design of substructures to produce a known and limited amount of settlement.

Bearing power and loaded area

It has been generally recognized by engineers that the bearing capacity of soil varies with the size of the loaded area. Qualitatively this variation has been generally expressed by the statement that the larger the area the smaller the bearing capacity. While an equation expressing this relation may not be generally accepted, the writer first used an equation for reproducing test results in 1927 which has since proved perfectly satisfactory in all cases encountered. This equation is a linear function involving the stress reactions of an indefinite body of soil to a surface load.

If bearing capacity and size of loaded area are related, it is fairly obvious that the geometrical properties of the area are of prime importance. These properties may be expressed by the perimeter-area ratio, a function precisely analogous to the hydraulic radius used in hydraulics to express the geometrical properties of a pipe or channel. The load carried by the area may be expressed as follows:

$$W = Ap = mP + nA \quad \ldots\ldots (1)$$

A = area in square feet.
P = perimeter in feet.
m = perimeter shear in pounds per linear foot.
n = developed pressure in pounds per square foot.
p = bearing capacity in pounds per square foot.

The equation is most conveniently expressed in terms of bearing capacity:

$$p = m\frac{P}{A} + n \quad \ldots\ldots (2)$$

In any discussion of static bearing capacity there are three variables to be considered—namely, load in pounds per square foot or bearing capacity, size of area or perimeter-area ratio, and settlement. Equation (2) contains only the first two of these, so obviously would only be true for constant value of the third variable, settlement. The general relation involving all three variables may be derived in terms of any one of three physical coefficients of the soil: coefficient of compressibility, modulus of shearing resistance or modulus of incompressibility. Dean C. C. Williams obtained a general equation of this nature (*Trans.* Am.Soc.C.E., Vol. 93, pp. 308-9) which is as follows:

$$\Delta = \frac{Wh}{I\,(b^2 + brh)} \quad \ldots\ldots (3)$$

Δ = settlement.
W = load.
h = depth affected by surface load.
I = modulus of incompressibility.
b = width of bearing area (assumed square).
r = tangent of angle of spread.

Equation (3) has several limitations,

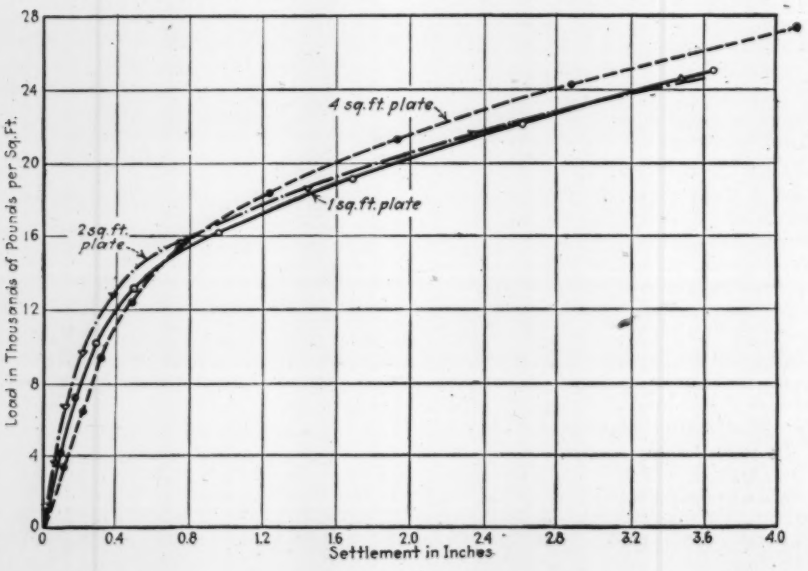


Fig. 1—Load-settlement curves determined by tests on three areas of 1, 2 and 4 sq.ft.

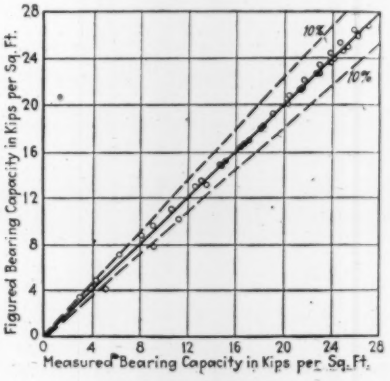


Fig. 2—Curves of straight-line equation compared with test results as shown by Fig. 1.

in that it contains quantities that are not measurable by test. These are the depth h, the modulus of incompresssibility, I, and the angle of spread r. All of these quantities might be assumed to be based on experimental evidence if it were available, but any series of soil tests on undisturbed soil in place must be interpreted without this information.

Equation (3) may be placed in more convenient form:

$$\Delta = \frac{K_1 p}{(1 + K_2 P/A)} \quad \ldots\ldots (4)$$

$$K_1 = \frac{h}{I} \qquad K_2 = \frac{rh}{4}$$

The quantities K_1 and K_2, which may be known as soil-resistance coefficients, must still be expressed in terms of quantities measurable by test.

The relation between equation (2) and equation (4) may be readily shown and the soil resistance coefficients expressed in terms of the stress reactions measured by actual test.

When settlement Δ is held constant:

$$\Delta + \frac{\Delta K_2 P}{A} = K_1 p \quad \ldots\ldots (4)$$

$$p = \frac{\Delta K_2 P}{K_1 A} + \Delta / K_1$$

From test data

$$p = m P/A + n \quad \ldots\ldots (2)$$

$$\therefore m = \frac{\Delta K_2}{K_1} \qquad n = \frac{\Delta}{K_1}$$

$$K_1 = \frac{\Delta}{n} \qquad K_2 = \frac{m}{n}$$

The term K_1 is designated as the coefficient of settlement and is defined as the ratio of the settlement divided by the developed pressure; K_2 is called the stress-reaction coefficient and is defined as the ratio of perimeter shear divided by developed pressure.

Proof of accuracy

For the purpose of demonstrating the accuracy with which the linear equation (2) expresses the results of actual tests, the writer has selected the results of a group of three bearing-capacity tests on round bearing areas of 1, 2 and 4 sq.ft. respectively. The soil tested was a fairly stiff blue clay, and the tests were conducted in open pits with confining influence due to static head entirely removed.

In Fig. 1 are shown the load-settlement diagrams for the three test areas. From these diagrams the loads for each particular area may be taken off for any given amount of settlement. Knowing the perimeter-area ratios, the linear equations of the form of equation (2) may be set up and solved simultaneously for the most probable values of the stress reactions m and n. There being more equations than unknowns, this solution involves the method of least squares, and the values may not satisfy exactly any of the equations but represent the best values for all tests. The accuracy with which the straight-line equation reproduces the test results is illustrated in Fig. 2, where the measured bearing capacity is plotted against the capacity computed from the equation, using the values of m and n determined by the above solution. If there was perfect agreement between the equation and test results, the points would fall along the 45-deg. line. Actually the agreement is not perfect but remarkably close, indicating an experimental error of much less than 10 per cent throughout the major portion of the range covered by the tests.

This agreement between the linear equation and test results is typical of the results of some fifteen series of tests that have been conducted under the writer's supervision and under a variety of soil conditions. While the soils tested have all been cohesive, they include types which vary from very soft plastic clay to a hardpan of the character of a soft rock conglomerate.

Evidence concerning the elastic properties of this particular clay and the definite bearing capacity it possesses is shown in Fig. 3*a*. Particular attention is directed to the fact that in the lower range of load the settlement for any given increment takes place very quickly after the load is applied. However, in the upper range of load there is evidence of progressive settlement throughout the entire interval between load increments. Attention is also directed to the elastic rebound of 0.46 in., which occurred after the load was removed at the termination of the test.

In Fig. 3*b* the various portions of the time-settlement diagram, corresponding to different intensities of load, are plotted in a special form for comparison, time in minutes being the vertical ordinate and settlement in

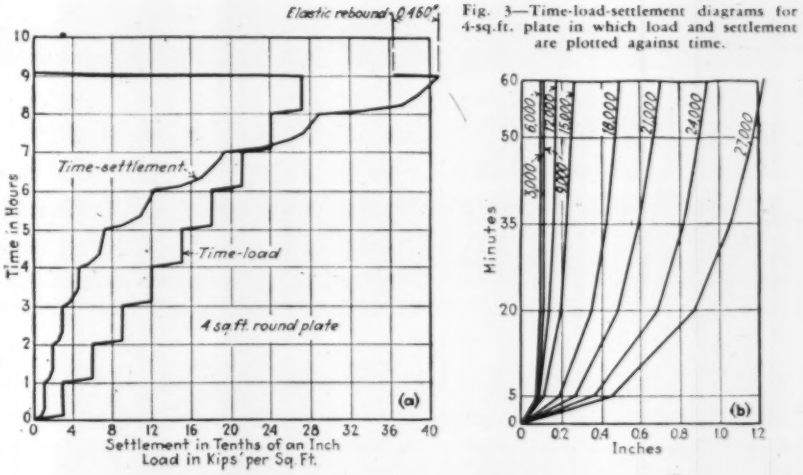
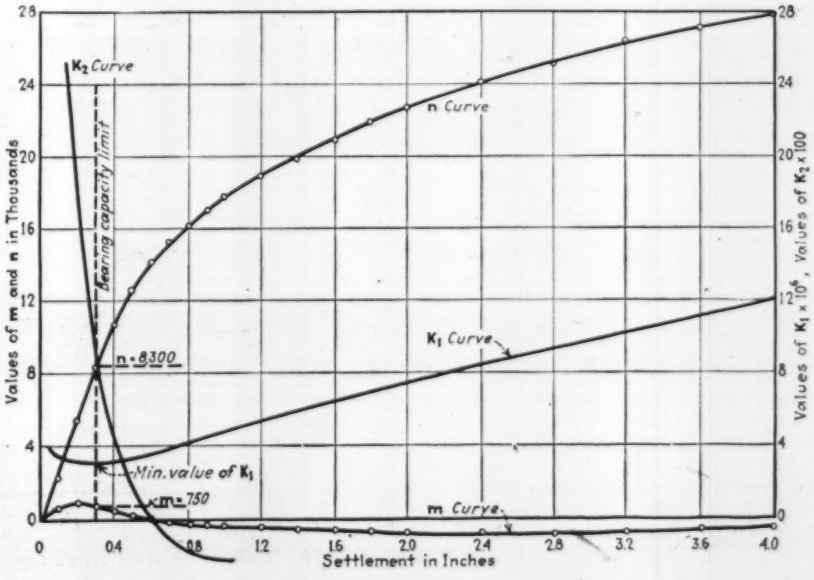


Fig. 3—Time-load-settlement diagrams for 4-sq.ft. plate in which load and settlement are plotted against time.

Fig. 4—Values of perimeter shear m and pressure n and related soil-resistance coefficients K_1 and K_2 plotted for entire range of settlements covered by tests.



inches the horizontal. The major portion of the settlement for the first three load increments of 3,000, 6,000 and 9,000 lb. per sq.ft. took place in the first 5 min. while the load was being applied. A small amount of settlement took place in the succeeding 15 min., with no measurable settlement occurring in the succeeding 40 min. of the regular time interval of one hour between applications of load. Of particular importance is the fact that the increments of settlement for the first three load increments are practically equal, indicating a straight-line relation between load and settlement typical of elastic behavior.

After the load had been increased to 12,000 lb. per sq.ft. the settlement appeared to be progressive throughout the entire period of constant load, and the rate of settlement increased progressively for succeeding load increments. The bearing-capacity limit of soil is defined as the load greater than which the settlement of a given bearing area becomes progressive. Based only on one test and the relation between load and settlement shown in Fig. 3, one might conclude that the bearing-capacity limit of the particular soil tested is between 9,000 and 12,000 lb. per sq.ft. for a 4-sq.ft. bearing area.

The subsequent analysis, including the results of all three tests, bears out such a conclusion. The next step in the routine analysis is shown in Fig. 4, in which the values of m and n obtained in the manner previously described have been plotted for the entire range of settlement covered by the tests. The m and n curves themselves furnish no criterion of the bearing-capacity limit, as there are no critical points in the usual curves to indicate which portion of the range of variation would result in progressive settlement. The related soil-resistance coefficients K_1 and K_2, which are also plotted in Fig. 4, do have maximum and minimum values that designate critical stages of bearing capacity.

In the case under discussion the minimum value of K_1 at a settlement of 0.3 in. sets the bearing-capacity limit. The two coefficients must be considered simultaneously in explaining why the minimum value of K_1 is critical; K_2, which is the ratio of m divided by n, is decreasing throughout the entire range of the tests. The greater rate of increase in developed pressure n designates it as the more significant of the two stress reactions. The developed pressure n becomes the controlling factor of increased capacity as loading continues. The coefficient of settlement K_1 is decreasing for the lower range of load, and, being the ratio of settlement divided by developed pressure, this variation indicates that pressure is being developed faster than the settlement is increasing. During this lower range there is then a margin of available bearing capacity in the stress reaction due to developed pressure n.

If the loading were discontinued at any point during this lower range, the margin of developed pressure is available to bring the bearing area to equilibrium.

When the loading is continued beyond the critical point set by a minimum value of K_1 the increasing values of this coefficient indicate a higher rate of increase in settlement than developed pressure and signify progressive settlement. The results of this analysis may be checked against the conclusion drawn from the time-load-settlement diagram of the 4-sq.ft. bearing area by substituting the critical values of m and n as taken from the data in Fig. 4.

When $\Delta = 0.3$ in., $m = 750$ lb. per foot, and $n = 8{,}300$ lb. per sq.ft.

For a 4-sq.ft. round area $P/A = 1.77$.

$$p = mP/A + n \quad \ldots\ldots (2)$$

$$p = 750 \times 1.77 + 8{,}300$$
$$= 9{,}630 > 9{,}000 < 12{,}000$$

Practical application

The series of tests used as an example were conducted by the city of Detroit, department of water supply, and were supplemented by a similar group of tests made under a condition of total confinement due to overburden. The results were then used to design the substructure for a 2,000,000-gal. elevated storage tank. The tank was supported by twenty columns equally spaced around the circumference. The substructure consisted of a continuous ring of reinforced concrete 21 ft. wide and 3 ft. thick. The outside diameter of the ring was 101½ ft., having then

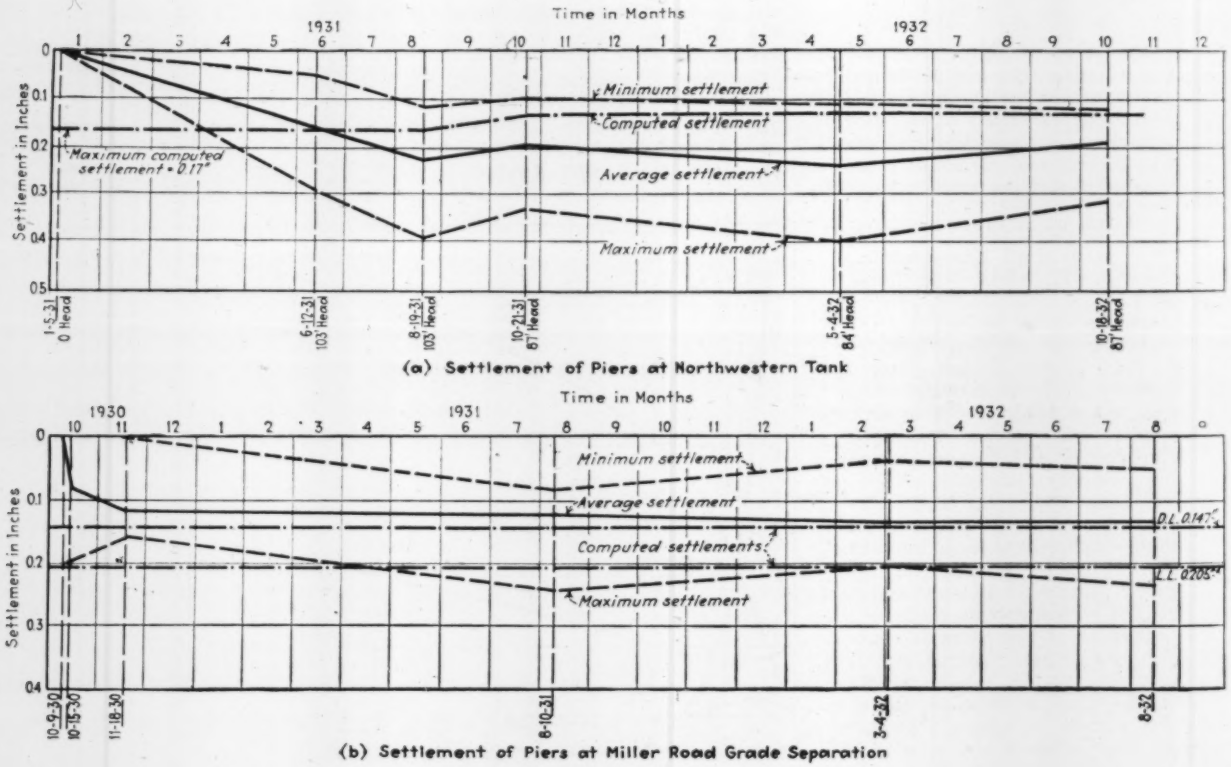


Fig. 5—Settlement, as observed at two structures, compared with predicted settlement.

a perimeter-area ratio of 0.095. The footing sustains a bearing pressure of 4,600 lb. per sq.ft., which, according to the soil-test data, would result in a settlement of about 0.17 in.

In Fig. 5*a* are shown the results of settlement measurements on the finished structure compared with the predicted settlement. The settlement is shown as the average of the readings taken at twenty columns as well as the maximum and minimum of individual readings. The tank was under construction until June 12, 1931, and was full from that date to Aug. 19, 1931. On Oct. 20, 1931, the tank was only partly filled, and there was a positive decrease in the total settlement interpreted as elastic rebound. Normally the tank is only partly full, the head varying between 80 and 90 ft. The average total settlement to date is 0.19 in., only slightly in excess of the design settlement. There has been no significant change in the settlement for the past year, the variation shown being assigned to compensating errors in levels run at the different dates.

Non-homogeneous soils

The method of interpreting soil tests as outlined in the preceding discussion has sometimes encountered the objection that the theory involved is limited by the arbitrary assumption of constant value of the physical coefficients of soil. As has been pointed out, the final equations contain no quantities that are not measurable by test. There still remains some question as to whether the theory involved is useful in any other than practically homogeneous soil conditions. Of course a series of tests conducted on a reasonably homogeneous body of soil is much easier to interpret, and the danger of overlooking significant changes in soil strata is much less. However, critical variations in soil strata have been encountered and the interpretation of the tests successfully accomplished.

In Fig. 6 are shown the m, n, K_1 and K_2 curves for a series of tests conducted by the Wayne County Road Commission in connection with the design of a major grade separation at Miller Road in Detroit. The soil conditions were somewhat out of the ordinary and were very critical for the construction of the large structure proposed. It was found necessary to place the pier footings on a layer of stiff red clay only 18 in. thick, which was underlain by a body of very plastic blue clay extending down to hardpan at a depth in excess of 100 ft.

Tests were conducted at the elevation of the stratum of stiff red clay in the hope that the mat action of this 18-in. layer would be sufficient to carry safely the superimposed loads. The results of the tests were particularly illuminating and showed two distinct bearing-capacity limits or critical points. The first critical bearing capacity is designated by a minimum value of K_1 at a settlement of 0.35 in. The minimum value of K_1 ($K_1 = \Delta/n$) represents the maximum pressure that the underlying material is capable of developing without progressive settlement. The values of m and n are 2,800 lb. per lin.ft. and 1,350 lb. per sq.ft. respectively.

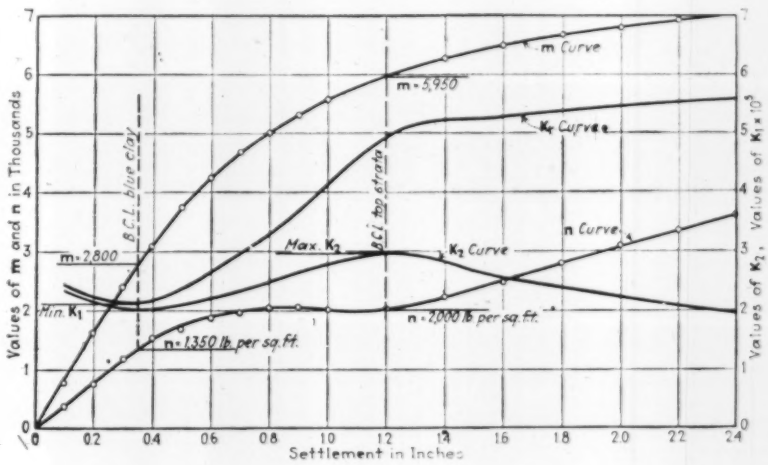


Fig. 6—Values of m, n, K_1 and K_2 for a series of tests conducted in connection with the design of the Miller Road grade separation.

As the loading continues, the developed pressure increases very slowly, and for a considerable range of settlement remains almost constant at 2,000 lb. per square foot, even showing a slight recession. In the meantime the perimeter shear shows a considerable increase, representing the shearing strength of the top layer of stiff red clay and portraying considerable ability of the top layer to distribute load to the underlying soil. The critical point of this later stage is designated by a maximum value of K_2 $\left(K_2 = \frac{m}{n}\right)$. The increasing values of K_2 are due to the fact that m is increasing faster than n and indicates a margin of strength due to the perimeter-stress reaction. The maximum value of K_2 and subsequent decreasing values indicate that this margin has been exhausted, and the bearing areas are on the point of shearing through the top layer.

On the bases of these test data 48 piers were designed as spread footings resting on the layer of stiff red clay and having a total soil pressure of 1,550 to 1,700 lb. per sq.ft. Settlement readings were taken of representative piers after the column seats were in place, and the measured settlement for the remainder of the applied load is shown in Fig. 5*b*. The predicted settlement is shown for dead and live load, and the favorable comparison between measured settlement and settlement predicted for dead load seems to indicate that moving live loads are of minor importance in causing settlement. There is shown the average settlement of all piers as well as the maximum and minimum of individual piers. The average total settlement to date is 0.135 in., slightly less than the computed settlement for dead load of 0.147 in. The settlement for the past year and a half is practically negligible and shows definitely that the settlement is not progressive at the present time. This fact is presented as evidence that this particular clay does have a definite bearing value. The favorable comparison between the measured settlement and predicted settlement is also a definite answer to the statement that soil tests cannot be correlated with the behavior of actual structures. Further than this it is significant that the latter example is taken from an investigation where the soil conditions were extremely critical and complicated by variations in the soil strata.

There are other examples of successful correlation of soil-test data and behavior of actual structures, which are just as enlightening as those given, but space scarcely permits the presentation of all the data available. In contrast with the examples given, of particular interest are at least two investigations of existing structures in which the actual pressure on the soil has been in excess of the bearing-capacity limit of the soil as determined by test. The result has in both cases been progressive settlement, which harmonizes in every respect with the laws of plastic flow, the rate of settlement being directly proportional to the overload.

In conclusion the writer wishes to express the opinion that investigators in soil mechanics would gain the confidence and cooperation of the practicing engineer more quickly if they put more emphasis on facts as contained in the ample data that are available or may be collected, and less emphasis on dogmatic theoretical statements unsupported by experimental evidence. While there may be some variation in methods of interpreting test data, it seems hardly possible to go far astray when carefully regulated tests are performed under the identical conditions which engineers expect their finished structures to perform.

Repercussions of Roadbuilding on Business Prosperity

A quantitative appraisal of production and employment in the stone, sand, gravel, cement, asphalt, steel, railway and machinery industries that are affected by highway construction

By J. L. Harrison
Senior Highway Engineer, Bureau of Public Roads, Washington, D. C.

WHAT influence does highway construction have on other lines of business? No categorical answer can be given. Some lines of business are considerably and very directly influenced; others are influenced only as the result of so long a series of transactions that to trace them to ultimate conclusion becomes difficult.

To illustrate, highway construction involves the use of many trucks. As a rule, these trucks are purchased through local dealers who have purchased them from manufacturers. The use of these trucks, then, has a direct influence on the volume of business handled by those who manufacture trucks. But, the manufacturers have purchased many of the parts used in making these trucks from parts manufacturers. They, in turn, have purchased steel from the steel mills, and the steel mills have had to secure the raw products (the flux, the coke and the ore) in various places from a widely scattered group of raw-materials producers. Even then the influence of highway construction has not been fully revealed, for the producers of the raw materials used machines of various sorts in handling their products, and the use of these machines introduces other ramifications, many of which are difficult to trace accurately or to evaluate correctly.

Some of the more important effects that highway construction has on industry and on business can be rather definitely appraised. To do this, the expenditures will be broadly classified as: (1) salaries and wages; (2) construction materials; (3) freight; (4) job haulage; (5) construction equipment; and (6) profit.

Salaries and wages

The money paid to employees is at once paid out for living expenses and moves from the retailer to the wholesaler and back to the producer. As this is written (December, 1932), it is estimated that at least 400,000 men are directly employed in the construction of the highways in which the federal and state governments are directly interested. Usually about an equal number are employed in connection with county road work and city street work. As the great majority of those employed are men with families, not far from 2,000,000 individuals are directly dependent on the joint state and federal highway program for a livelihood. Or, in terms of commerce and business, nearly 2 per cent of the nation's current volume of business in the things people eat and wear and use is based on the salaries and wages paid to highway employees. If, as is usually the case, the number of those dependent on city, town and county work is about as large, nearly 4,000,000 human beings must today depend quite directly on highway work for their livelihood.

● The magnitude of roadbuilding expenditures has made them a favorite target for the economists of the local Chambers of Commerce and the daily press. "We have all the roads we need! "Roadbuilding doesn't help business or unemployment!" and "We are spending too much money on roads anyway!" are reiterated as self-evident truths. Therefore let us take the tolls that the motorists are paying for road improvement and give the money to men out of work. If we need to give more, then make the motorists pay higher tolls. With plenty of money for doles we need not worry any more about our neighbor without a job or the men we laid off.

● Perhaps the Chambers of Commerce and the editorial writers should not be blamed for not projecting their thinking any farther abroad. Most of the people have even narrower brain horizons. But hope is an eternal spring, and a student of the incidence of benefits that come from spending road money for roads has prepared for us a statement of how far business and employment are affected by this procedure. The facts are presented very simply and plainly so that anyone can understand them; and some of our readers, who know Chambers of Commerce and editors that hold the beliefs indicated, can perhaps use them profitably in spreading economic conversion.

—EDITOR.

Stone, sand and gravel

In 1929 the production of crushed stone for concrete and road work, as given by the Bureau of Mines, was 76,174,770 tons, valued at $80,685,493 at the quarries. This is a little more than 50 per cent of the nation's stone production. During the same year 40,801,991 tons of paving sand was produced (slightly over 40 per cent of the total sand production of the country) and 60,029,164 tons of paving gravel (slightly under 50 per cent of the total reported production). This figure for gravel production does not include local bank gravels used in gravel road construction, these being as a rule purely local operations worked only when road construction in the immediate vicinity is in progress.

During years of normal business activity nearly half of the nation's sand, gravel and broken-stone industry is based on road and street construction and maintenance. During 1931 crushed stone sold for concrete and road metal amounted to 65,811,520 tons out of a total production of 95,933,180 tons, or nearly 69 per cent of the total stone production. The production of sand for paving work was 27,459,581 tons out of a total production of 64,493,826 tons, a little less than 43 per cent. Gravel for paving amounted to 56,716,230 tons out of a total production of 88,986,218 tons, or about 64 per cent of the total reported gravel production.

While figures for the current year's business are not yet available, there is every reason to believe that highway construction is today creating an even larger fraction of the demand for these materials, so that, in round numbers, probably 75 per cent of the business handled by the crushed-stone, gravel and sand industries originates in the field of road and street construction and maintenance.

During 1929 the quarry industry employed a little over 85,500 men on an average of 268 days each. Of these about 54,500 were employed on the production of non-dimension stone, of which nearly 60 per cent was for concrete and road work. It seems reasonable to conclude that more than 30,000 of the men then employed in this industry were dependent on highway construction for their livelihood. The demand for stone for concrete and road metal has fallen a little over 10 per cent. The demand for labor has, no doubt, been similarly reduced; but even after making due allowance for this, it would appear that at least 25,000 men are still at work on the production of crushed stone largely used for highway work.

The figures presented by the Bureau of the Census of the sand and gravel industry in 1929 indicate that 19,628 persons were employed in the production of 165,526,074 tons. Reports were not obtained on organizations shipping

less than 25,000 tons a year. The amount of labor used in the larger sand and gravel plants per ton of material produced usually is less than it is in the smaller plants, and therefore the total employment in producing the 222,571,905 tons of sand and gravel reported by the Bureau of Mines must somewhat exceed 26,500 people, of which about 45 per cent or some 12,000, would appear to have been dependent on road and street construction for employment. The production of sand for paving purposes was somewhat reduced in 1931, but the production of gravel had fallen less than 10 per cent, indicating that employment in the sand and gravel industry on account of highway construction still exceeds 10,000 full-time men.

A YEAR'S BUSINESS FROM ROADBUILDING

Nearly four million people depend quite directly on highway work for their livelihood.

Half, or 76,000,000 tons, of crushed stone produced by commercial quarries was used in road construction.

Four-tenths, or 41,000,000 tons, of the commercial sand production was sold for road construction.

Road construction consumed 60,000,000 tons of gravel, or nearly half of the commercial production.

Of the 127,000,000 bbl. of cement shipped, 70,000,000 bbl. was shipped to roadbuilding operations.

Asphalts and asphaltic oils used in highway work amounted to 50 per cent of the total production of 5,000,000 tons.

About 15 per cent of the tonnage moved by railway consisted of roadbuilding materials and machinery.

The annual expenditure for roadbuilding machinery is $50,000,000.

And these are the large items only.

Cement

During 1929 the cement mills of this country shipped about 170,600,000 bbl. of cement. Imports exceeded exports by about 500,000 bbl., so consumption was presumably in the neighborhood of 171,000,000 bbl. This figure takes no account of retailers' stocks. However, these are not a large factor in the cement industry and presumably do not vary greatly from year to year.

Reports of the Portland Cement Association indicate road, street and alley construction during 1929 as follows: roads, 92,316,794 sq.yd.; streets, 43,543,570 sq.yd.; alleys, 3,660,387 sq.yd. To this must be added a considerable yardage of concrete bases not included in the above, as well as a considerable amount of bridge culvert and miscellaneous work in which cement is used. It is estimated that this work required between 60,000,000 and 65,000,000 bbl. of cement, of which rather more than half, or perhaps 35,000,000 bbl., was used on highways, bridges, culverts and miscellaneous structures. These figures would suggest that in 1929 nearly 40 per cent of the nation's cement business was occasioned by highway, street and alley construction, including bridges, culverts and miscellaneous structures built in connection with these improvements. Somewhat more than half of this, or about 20 per cent of all cement sales during 1929, was on account of highways, highway bridges and culverts constructed as a part of the state highway programs.

The records of the Bureau of Public Roads show that during 1931, 9,664 miles of concrete surfacing was constructed on the state highway system. If concrete bases for brick and for bituminous concrete surfaces are added, over 10,000 miles of pavement requiring the use of cement were laid down. If to this there is added the cement used in building bridges, culverts, gutters and minor structures, it is apparent that the state highways, including those on which federal aid was spent, required not far from 45,000,000 bbl. of cement. Ordinarily city, town and county work require more than 30,000,000 bbl. of cement; and while this demand probably was somewhat reduced in 1931, it nevertheless is reasonable to presume that the total used on roads, streets, alleys, bridges and minor structures still was not far from 70,000,000 bbl., or over 55 per cent of the 127,150,534 bbl. reported by the Bureau of Mines as shipped during 1931.

During the current year the shipments of cement have suffered further sharp reductions, only 64,219,000 bbl. having been shipped during the first nine months, as reported by the Bureau of Mines. Highway work has been somewhat reduced, and city and county work more so; but even after making full allowance for these reductions, it would appear that currently not much under 70 per cent of the business that the cement companies are receiving comes from the highway field. Here, as in the stone, sand and gravel industries, the position of an important industry and of some 40,000 employees directly attached to it (1929) would be most serious if this business were withdrawn.

Bitumins, steel and lumber

Of the 1929 business in asphalts and asphaltic oils, which in volume exceeded 5,000,000 tons and in value exceeded $50,000,000, something over 2,500,000 tons valued at about $30,000,000 was used in road and street construction and maintenance. These figures indicate that in volume about half of the country's asphalt business, in value about 60 per cent of it, originated in street and highway construction and maintenance. Undoubtedly the percentage of the total volume of business originating in the highway field is larger now than it was in 1929.

Much the same may be said of the country's extensive use of tar, of which a considerable fraction is used in surfacing roads and streets.

The known statistics on steel, lumber and fuel throw little light on the amount of these materials required, except that preliminary studies of the materials used in state highway construction during 1931 appear to indicate that about 500,000 tons of steel was used in steel structures and as reinforcing. But this is only a fraction of the total use of steel generated by the highway construction program, for it takes no account of the steel used as parting strip, dowels, etc., or of other minor uses. Quite a tonnage is used in corrugated metal culverts. A large tonnage is also used in the wagons, trucks, tractors, trailers, cranes, shovels, mixers and other tools and equipment used in the construction and the maintenance of roads and streets, to say nothing of the tonnage that goes into the equipment of quarries, gravel and sand pits, cement mills and other industries that serve the highway field.

A good deal of lumber is used in connection with highway construction. Most of it goes into miscellaneous temporary structures. A good deal is used in building forms for bridges and culverts. A little is used for semi-permanent bridges and culverts. Some is used in guard-rail construction and other minor structures. In total, the amount used runs to many million board-feet a year.

Fuel

Fuel is used in the production of power. For August, 1931, reports on 5,245 active projects on the state highway system indicate that in addition to other equipment the following were used: 2,150 shovels, 1,175 cranes, 700 paving mixers, 1,750 other mixers, 1,775 road rollers, 24,500 trucks and 5,450 tractors.

It is reasonably certain that the power plants on these machines are capable of developing at least 2,000,000 hp. In addition, there is a large amount of other equipment that is power-driven. It is, therefore, reasonable to estimate that at its peak the 1931 state highway program utilized equipment that is capable of developing, and at times did develop, over 2,500,000 hp. The 1932 highway program is not as large as the

1931 program, but probably the equipment used this year has at its peak involved the use of a power plant capable of developing more than 2,000,000 hp. As most of this equipment used gasoline as fuel, it is apparent that a considerable volume of gas and oil business is generated by the current highway program. Practically all of this business is handled by local distributors and assists these men in maintaining their volume of business in this important field.

Railway transportation

A large part of the material used in constructing highways is moved a considerable distance by rail. Some of the items moved by rail during 1929 and during 1931 (as shown by Interstate Commerce Commission reports) are as follows:

	Tons, 1929	Tons, 1931
Gravel and sand, not including glass and molding	81,408,069	53,562,437
Stone—broken, ground or crushed	33,529,078	25,860,716
Asphalt	3,196,392	2,745,541
Fuel, road and petroleum residual oils	13,477,520	9,632,285
Machinery	3,930,942	1,943,221
Cement	25,008,203	18,391,904
Tractors	637,627	273,283
Auto trucks	276,634	105,621
Explosives	319,836	208,971

In all of these items, as well as in many minor items that have not been listed, the traffic generated by highway and street construction is large. In some of them (sand, gravel, stone, asphalt and cement) the 1931 tonnage generated by road and street construction undoubtedly exceeded 60 per cent of the total 1931 tonnage carried. In only the items listed above would it therefore appear reasonable to conclude that not far from 65,000,000 tons of car-load freight, or between 7 and 8 per cent of the 1931 car-load business, was derived from the highway field. Non-listed items of course yielded a considerable additional tonnage. For instance, at least 450,000 tons of steel (possibly 500,000 tons) was used on the state highway system alone during 1931. Practically all of this was delivered by rail.

To make this steel, the ore, coal, flux, etc., had to be accumulated. Most of these move over the railroads. Each ton of steel and each ton of equipment represent several tons of freight moved before the finished product was carried to its destination. The amount of railroad business directly generated by the present activity in the highway field is therefore much greater than the 65,000,000 tons noted above.

Finally the railroads handle a considerable volume of business in the way of materials delivered to those concerns that supply the highway field. Just how important all of this is, as expressed in freight tonnage, it would take too much space to recite here. However, it is at least not improbable that more than 15 per cent of the tonnage moved by rail during 1931 was generated by activity in the street and highway field, and the relative importance of this business is greater now than it was then.

Construction equipment

In August, 1931, reports from 5,245 active highway projects indicated that 14,500 teams, 24,500 trucks and 5,450 tractors were at work principally in moving materials to the points at which they were to to be used in the finished road. Road work is hard on hauling equipment. Many of these units will last less than three years. Normal replacements will, therefore, demand from 7,000 to 8,000 new tractors and trucks and a considerable number of teams and wagons.

In addition to those used on state highway construction, the demands of the industries that produce materials, equipment, etc., for road and street work are such that a considerable number of trucks used by them are really working in the interest of highway construction. Street construction and road and street maintenance also require a large number of trucks. The total number of trucks actively engaged on highway work is probably not far from 100,000 units altogether. If this is true, annual replacements are not less than 25,000 units.

In addition to hauling equipment, a large amount of machinery, equipment, tools, etc., is required in the construction of roads and streets. The value of the tools and equipment required varies with the type of work performed. A wheeler outfit handling excavation only will occasionally have an investment in tools and equipment (wheelers, a blade grader, a plow or two, and a few hand tools) that does not exceed $2,000. Elevating grader outfits, exclusive of hauling equipment, will usually show an investment in tools and equipment of over $5,000. Shovel outfits will show an investment in tools and equipment that will amount to several times this figure. An analysis of the cost of the equipment in use on 122 grading jobs selected at random showed an average cost (exclusive of trucks and tractors) of somewhat less than $20,000. Concrete paving outfits average an investment, exclusive of hauling equipment, that is a little over $50,000. A modern asphalt-paving outfit of good size carries a somewhat larger investment in plant tools and equipment. From these and other data of a similar nature it would seem that the cost new of the equipment used on the average highway construction project is well over $30,000.

With a maximum of about 5,500 projects active during 1931, it would appear that tools and equipment were used that originally cost not less than $160,000,000. The current construction program is probably utilizing equipment that originally cost at least $125,000,000. Bureau of Internal Revenue tables give the probable useful life of the great bulk of this equipment as from four to six years, though a little of it is assigned a useful life somewhat greater than this. An average life of five years is at least as long as most contractors would assign it. On this basis the depreciation on the equipment now in use must be in the neighborhood of $25,000,000, which for an industry as large as the highway construction industry must be accepted as indicating the amount that should be spent each year for new equipment if the investment is preserved.

When to this sum is added the sum required for the replacement of equipment used in building county roads and city streets and the equipment used in maintaining these roads and streets, the annual expenditure must exceed $50,000,000.

Beside this business, equipment builders derive a considerable volume of business on account of equipment worn out on the railroads, in the quarries, the gravel and sand pits, the cement mills, the steel mills, etc., in all of which industries materials are produced or work is performed in the interest of road and street construction and road and street maintenance.

Profit

Of the very narrow margin of profit that highway construction provides, little need be said. A firm's accumulation of job profits provides the salaries for the office force, interest on borrowed capital, the salaries paid the managers and, if anything is left, the net profit that has, in the past, provided the funds out of which the investment in the business has been expanded to meet an expanding highway program. Just at present the margin of profit in highway work is too narrow to provide much, if any, net profit.

This discussion has dealt only with the more obvious influences of highway construction on the nation's business—the direct and positive effect of a large highway program on employment and on the volume of business in lines that directly serve the highway construction industry. If this discussion were continued to show the secondary and the tertiary effect of the present highway program—that is, for instance, the maintaining of a good volume of business in the cement industry and in the industries that serve the cement idustry—it would be foud that a large highway program is of definite assistance to business all the way back to the producers of raw materials—the farmer, the miner, the cattle-raiser and the quarryman—whose current market, though admittedly unsatisfactory, is definitely improved by the business that originates in the construction and in the maintenance of roads and streets. If the volume of the business that these men do should also be reduced, the unescapable result will be that business in general—which in the last analysis means all of us—will suffer.

Intricate Intersections on Queens Parkway System

Parkway system of 24 miles requires 78 street-crossing bridges and great variety of route arrangements for interchange of intersecting traffic

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RIGID adherence to universal grade-separation at all intersecting highways forms the keynote to the design of the arterial parkways being built in Queens Borough, New York City. Only thus can traffic be passed straight through Queens without a stop. As stated in the preceding article (*ENR*, Feb. 16, 1933, p. 209) three of these routes are under way, with state assistance, in addition to many other important traffic arteries, to care for a rapidly growing automobile traffic and to diminish what is fast becoming an intolerable congestion on Sundays and holidays. The three main high-speed arteries involve 24 miles of route in Queens Borough. They connect Manhattan, Brooklyn and the Bronx, through Queens, with Nassau County and other territory to the east of the New York City line on Long Island.

On the 24 miles of this system there are 78 bridges for the sole purpose of keeping grades separate at intersections. Of these, nineteen will be on the Interborough Parkway section. Fifteen will provide the main stem of Grand Central Parkway with crossings of as many north-south streets; three are in the elaborate separation of grades just east of Kew Gardens; twelve are on the northerly extension of Grand Central Parkway; eleven are on Astoria Boulevard, as Triborough Bridge is approached; and eighteen are on Sunrise Highway.

Several different designs have been used for joining the service or access drives into the high-speed roads and for connections between the latter and intersecting highways. They vary from straight ramps and the conventional cloverleaf to an elaborate layout more than half-a-mile long providing interconnection among several major highways and their respective service roads. Each design is predicated on the local topographical conditions.

Speaking generally, it is an easy matter to drop the center road and pass under an intersecting highway out in the country or elsewhere where adequate space can be had. This requires a width of 150 or 160 ft. or more if the crossing must be elaborate. But rarely can it be done in cities already built as is most of Queens, without incurring inordinate expense for condemnation of the requisite land and structures.

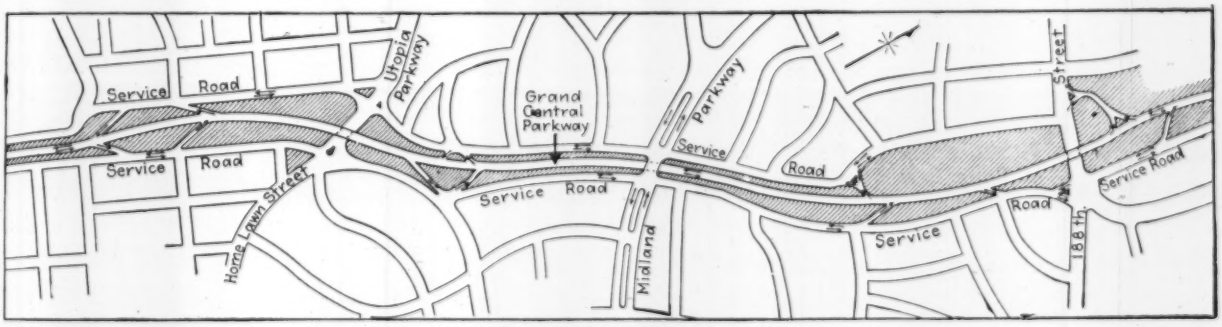

Fig. 1—Group of three crossings, with twelve ramps or other connections between service roads and parkway but no immediate connection between intersecting roads. Intercommunication requires short travel on service roads. Hatching denotes landscaped areas.

Several of the crossings, illustrated as showing the different methods imposed largely by topographical or other local conditions, will be described briefly in the following paragraphs. If most of them are concerned with Grand Central Parkway, it is because that project is further along in execution than the others. Half of its crossing bridges have been completed, and all of the others are in various stages of progress. Its grading is substantially finished, and paving is scheduled for completion during this winter. Its contour is gently undulating, rising from an elevation of 73 ft. at Queens Boulevard to 251 ft. about 6½ miles east of there, and close to the line separating New York City from Nassau County.

The simplest of all the crossings, of course, are those that provide for no immediate connection between the intersecting roads. This is the case where Grand Central Parkway crosses Midland Parkway, and there is only a single set of ramps, midway between 164th St. and 168th St., to serve both these crossings. The Midland Parkway crossing is shown by Fig. 1, which depicts, chiefly, the ramp connections flanking Utopia Parkway on the west and 188th St. on the east.

This section of a little more than a mile along the new parkway has three direct crossings, at intervals of some 1,700 and 2,300 ft., each with its bridge and twelve ramps or other connections between the express roadway and the marginal or service roads. There is only one direct access between the parkway express route and the three intersecting highways, but intercommunication is had readily by using the service roads for a short distance.

One of the simplest connections on all these routes is that shown by Fig. 2*M*, the crossings of 164th and 168th Sts., 1,500 ft. apart, over Grand Central Parkway. Here again there is no direct access between the parkway road and the intersecting streets. But access is had readily, by way of the two service roads, through "off" and "on" ramps midway between the two cross-streets named. By careful designing of the grades of the service roads the ramps may be made short—in this case, they are only 60 ft. long.

A different type of connection is used where Interborough Parkway intersects Woodhaven Boulevard and Myrtle Ave. Here the ramp has the entire difference in elevation to overcome, from the one road to the other. Hence (Fig. 3) it is much longer (reaching in one case about 400 ft.) than those shown in Fig. 2*M*. As in nearly all the other cases, the ramp road surface is made 22 ft. wide, allowing for two lanes of traffic. Each is a one-way street, to avoid introducing any interference into the parkway traffic in its steady uninterrupted flow. The grade difference between intersecting highways is customarily about 18 ft., allowing a 14-ft. clear passage under the bridge at center.

Something of a modification of the long ramp connection is found at the intersection of Grand Central Parkway extension with 69th Rd. in the Flushing River Meadows (Fig. 2*A*). Here the ramps afford intercommunication between parkway and service road on one

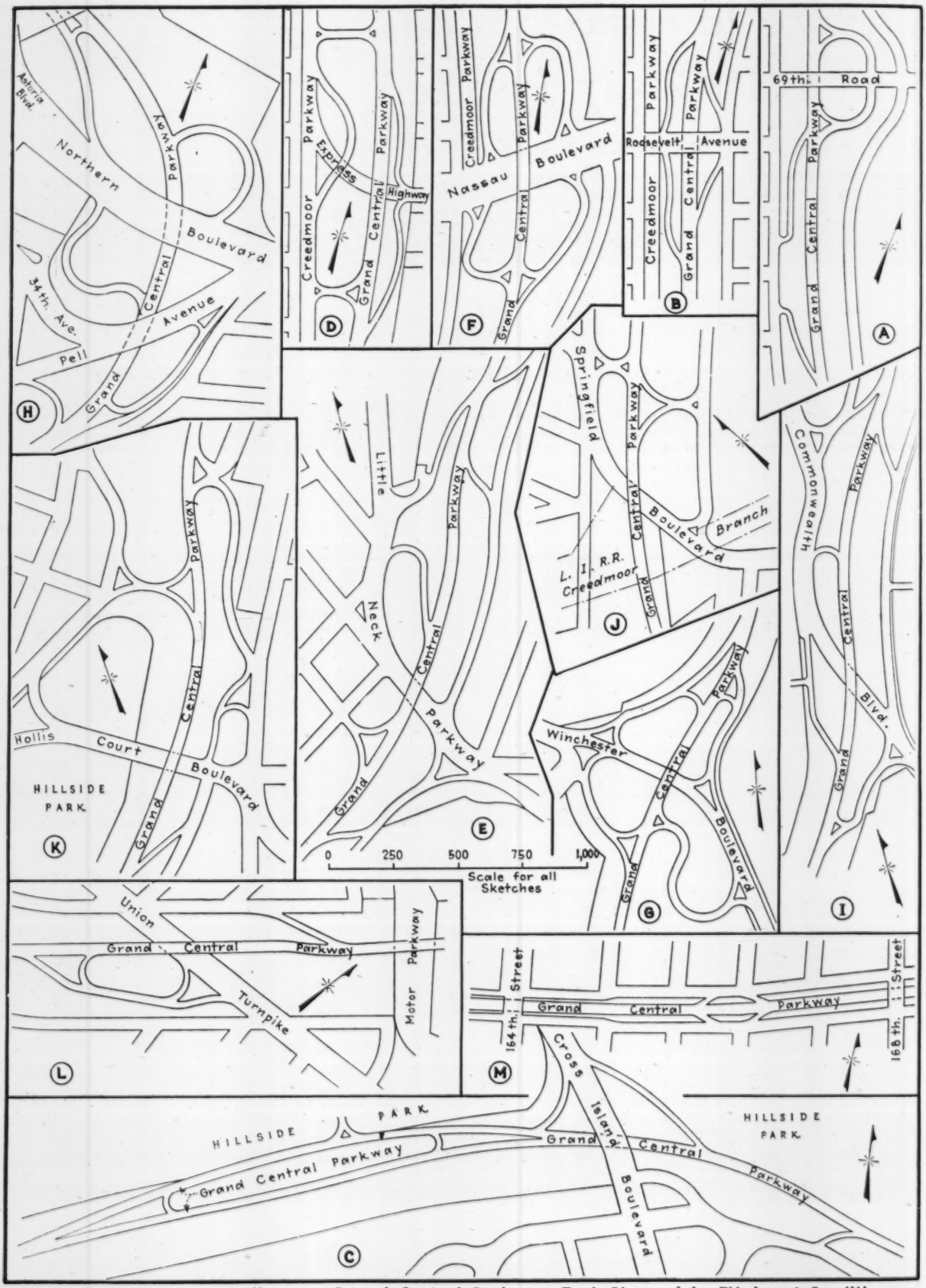

Fig. 2 – Thirteen Intersections on Grand Central Parkway, Each Planned to Fit Local Conditions

side, while the 340-ft. lengths in a pair of semi-circular loops are used to overcome directly the grade difference between the parkway and 69th Rd. By splitting these 30-ft. two-way loops into two 22-ft. roads at the points where they debouch upon the parkway, exchange of traffic is effected without confusion and without crossed lines of movement.

These loops are similar in their operation to the two-leaf clover effect found where Interborough Parkway crosses Metropolitan Ave. at the edge of Forest Park (Fig. 4). These cloverleaf approaches are longer, however, (more than 400 ft.) resulting in easier grades. And a case of the long ramps, making direct connection between the express

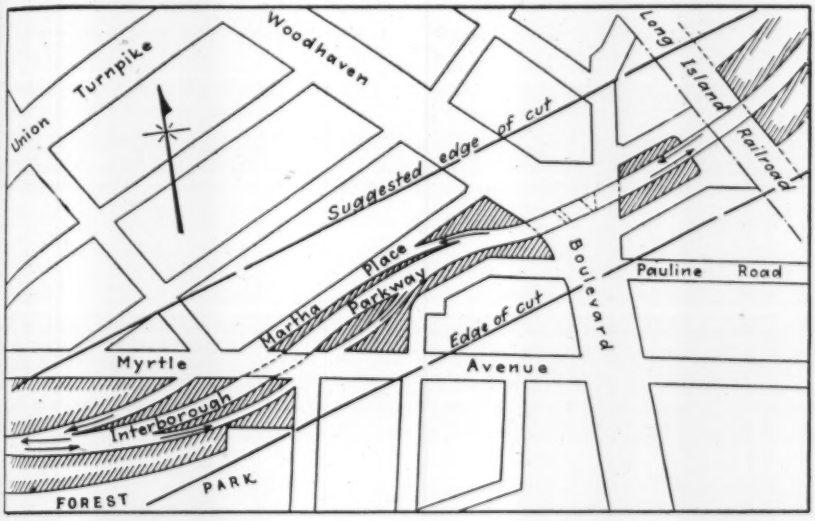

Fig. 3—Two adjacent intersections at which long ramps and bordering streets provide for interchange of traffic.

road and the intersecting road, is found in Fig. *2B*. Here, where Roosevelt Ave., with its elevated transit line, crosses Grand Central Parkway, the four long ramps (250 ft. on one side and 450 ft. on the other) afford access, both "on" and "off," for traffic in both directions.

A different arrangement of ramps, accompanied by the only deliberate "turn-around" in the whole route, appears at Cross Island Boulevard and the entrance into Hillside Park (Fig. *2C*). On the north side of the parkway the connection is direct with the boulevard; hence the ramps are given the requisite length (one of them is more than 550 ft.) to overcome the difference in level without troublesome grades. On the south side a shorter ramp is possible, as the connection is with the service road, and that, in turn, overcomes a part of the grade difference. To the west of this crossing is a bifurcation of the parkway, with short turn-around access roads for traffic in each direction. This not only permits cars to retrace their routes but also allows access, from both directions, with the park to the north.

Another combination of long ramps and short ramps is found at the crossing with Creedmoor express highway (Fig. *2D*). Here the short ramps, on the west side of the parkway, are in duplicate, to give access back and forth on both sides of the express highway; and a further crossing of the highway is made for the benefit of north-bound traffic along Creedmoor Parkway. It should be noted that this express highway is a future addition to the routes to be built for non-stop traffic.

In an unusually difficult territory, because of the sharpness of the hills, seven access ramps are provided where the parkway crosses over Little Neck Parkway, near the eastern edge of Queens Borough. As shown in Fig. *2E*, some of these ramps, notably in the northern part of the diagram and on the west side of Grand Central Parkway, had to be made unusually long; while on the other side the service roads assist in overcoming the grade difference. On both sides of this intersection Little Neck Parkway is climbing rapidly to surmount the ridge to the northwest, and the grades are severe. Only 900 ft. south of the crossing Little Neck Parkway is 75 ft. lower than Grand Central Parkway at the intersection. But it tops the ridge at an elevation well above that of Grand Central Parkway.

Loop designs

There are two excellent examples of the famous four-leaf-clover crossing—one at Nassau Boulevard and the other at Winchester Boulevard (Figs. *2F* and *2G*). They differ markedly in detail, owing to the great variation in topographical conditions at the two places. But they are alike in that each has four two-way access drives and that each drive is split, at each end, into two one-way connections with the parkway or the intersecting road. In neither case is the service road brought

Fig. 4—Two-leaf clover intersection of parkway and Metropolitan Ave.

into the interchange of traffic. On the southeast the access ramp at Winchester Boulevard is unusually long (about 750 ft.) to overcome an elevation difference of about 40 ft.

An interesting variant of the four-leaf type is that at Northern Boulevard, where for the present the Grand Central Parkway extension is to end. At this point converging avenues from the west make a complicated crossing unavoidable; but it has been accomplished with only two bridges, by which Northern Boulevard and Pell Ave. (merged with 34th Ave.) are carried across the parkway. This is shown in Fig. *2H*. At the northwest corner of the diagram dotted lines show where the parkway will eventually be carried on toward Triborough Bridge.

Still another variant of the same general idea occurs at Commonwealth Boulevard (Fig. *2J*). The boulevard ing is at an unusually acute angle. On the southeast the service road is brought into use in passing east-bound traffic from boulevard to parkway. Only one exit from the parkway, in each direction, is provided.

Looping entrances and exists, one of each on each side of the parkway, feature the crossing over Springfield Boulevard (Fig. *2J*). The boulevard has a fairly stiff climb from the south, rising about 26 ft. in the 550 ft. next south of the intersection. This climb of the boulevard northward accounts for the difference in length between the two access drives. Far below this intersection, and in a position which ultimately may result in a three-level crossing, lies the abandoned right-of-way of the Creedmoor branch of the Long Island Railroad. This is the route of the (projected) Creedmoor express highway. A similar set of looping entrances and exits will be found at Hollis Court Boulevard, but with one additional ramp between Grand Central Boulevard and the south service road (Fig. *2K*).

A combination of loop on one side and ramp on the other occurs at the crossing of Union Turnpike (Fig. 2*L*). This does not provide for access of traffic from the turnpike to the west-bound lanes of the parkway. To make this transfer, which would not often be called for, one has to follow the north service road to Springfield Boulevard, 2,000 ft. west. No interconnection in either direction is made here between Grand Central Parkway and the privately owned Motor Parkway, a toll road.

A complex example

There remains one other crossing to describe. In many ways it is the most interesting, as it certainly is the most complicated, of all those along Grand Central and Interborough Parkways. Popularly known as the "Pretzel," this series of crossings involving Grand Central Parkway, Grand Central Parkway Extension, Interborough Parkway, Union Turnpike and Queens Boulevard, is located at the eastern side of Kew Gardens, in the very heart of Queens Borough. Complete separation of all express traffic crossings has been accompuished here with the use of only four bridges—three in the Pretzel proper and the fourth where Queens Boulevard is carried across above three express highways.

As will be seen from the diagram (Fig. 5), traffic to and from the east (Nassau County and beyond) is along both Grand Central Parkway and Union Turnpike. This latter is an ordinary 100-ft. street east of this intersection. But it is split here into four parts—east-bound and west-bound express roads, each flanked by its corresponding service road. In this form, with certain modifications, it is carried west for 1½ miles, about one-half of which distance is shown on this diagram.

Meanwhile traffic to and from the northwest (the route, eventually, to Triborough Bridge) has a single artery—Grand Central Parkway extension. And traffic to and from the west (Brooklyn) is carried on both Union Turnpike and Interborough Parkway, the latter being considerably south of the turnpike at the Brooklyn Borough line.

By following the arrows on the diagram this transfer of traffic becomes clear. Cars from the east, going to Triborough Bridge, move right through along Grand Central Parkway, passing under the eastbound lane of Union Turnpike, keeping straight ahead at the star in the center of the diagram and then under the west-bound lane of Union Turnpike. Cars from the east, going to Brooklyn, keep left at the star, thus entering Interborough Parkway and passing under Queens Boulevard. If they are to go farther north in Brooklyn, making the Union Turnpike route preferable, they trend right at the star, thus entering Union Turnpike and passing along the right lane under Queens Boulevard. Cars from the east desiring to enter Queens Boulevard take this same Union Turnpike turn at the star and then enter the local or service road leading directly into Queens Boulevard.

Cars from the west, along Interborough Parkway and going to Nassau, continue right along past the star. To reach Nassau via Union Turnpike, the route is chosen some distance west of Queens Boulevard, and then the turnpike express overpass above Grand Central Parkway, near the east end of the diagram, carries them directly into their objective. Cars from Interborough Parkway destined for Triborough Bridge make a sharp loop to the right, at the star, and are at once started on their way. Any of this eastbound traffic headed for Queens Boulevard change some distance west of it to the Union Turnpike local road and does not pass under Queens Boulevard at all.

Traffic from Triborough Bridge (Manhattan, the Bronx, Westchester, etc.) going east to Northern State Parkway, continues straight ahead, taking the left or main fork at the cross (near center of diagram). Here the right fork throws those cars into Union Turnpike, east-bound. Cars from Triborough Bridge, turning to the right after passing under west-bound Union Turnpike, go directly into Interborough Parkway and thence to Brooklyn. For a destination farther north in Brooklyn the shift to Union Turnpike or to Myrtle or Metropolitan Aves. can be made considerably west of Queens Boulevard. Or Union Turnpike can be entered by keeping right at the cross and then swinging left around the loop 800 ft. farther east. This loop also permits a complete turn-around back toward Triborough Bridge.

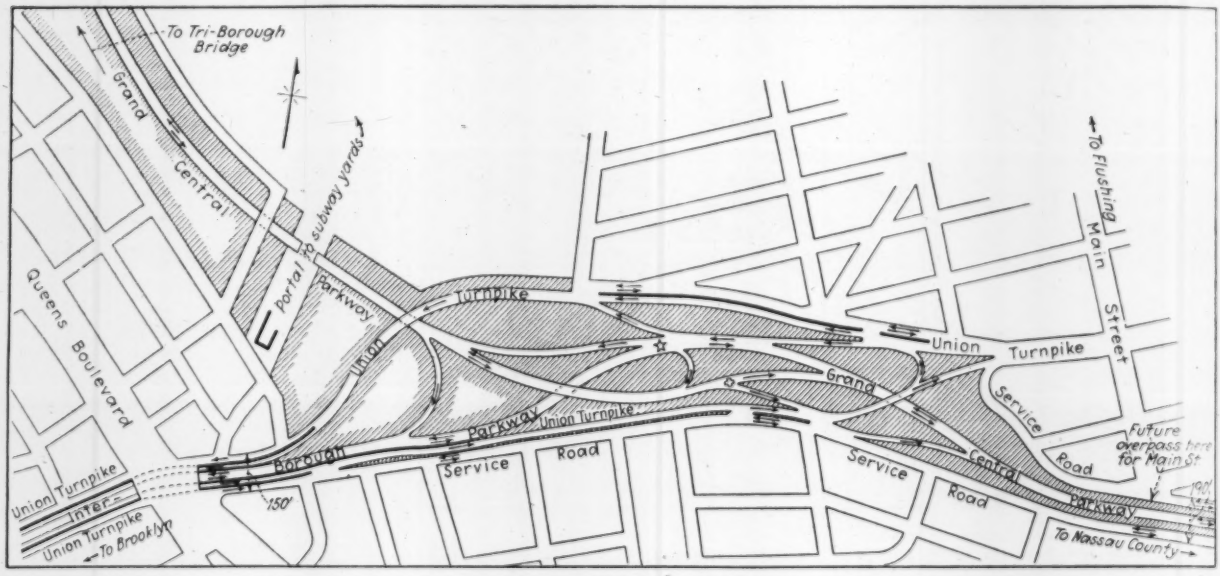

Fig. 5—Series of intersections of five thoroughfares accomplished with only four bridges and with complete interchange of traffic. Located just east of Kew Gardens.

Such a complex crossing will require an unusually complete and specific set of sign posts. It is planned to locate these posts far enough ahead of the road separations so that cars may continue at high speed and with full confidence that the correct route is being followed.

An unusual feature in this layout is the provision of five parallel roads (four of them one-way roads) for some distance each side of Queens Boulevard. All three roads passing under the boulevard bridge (now under construction) are express roads. The local roads, on the flanks of the quintet, are separated by walls from the high-speed through roads as the grade changes carry them up to the Queens Boulevard level. That level is considerably higher than the land for several hundred yards to the eastward, but the roads coming from the west must make a sharp dip to pass under the boulevard.

In all the diagrams the areas shown shaded are to be landscaped with trees, shrubs and lawns. This beautifying of the routes is a part of the state's contribution to the work. The city of New York furnishes the land required for the parkways, and the state is doing the physical work of construction. All of these routes were laid out in the Topographical Bureau of Queens under the general direction of the writer, assisted by Albert E. Thomas, principal assistant engineer, and Albert H. Chandler, engineer of designs. Mr. Chandler has been responsible for the detail studies resulting in the various grade separations along the entire route.

* * *

WITH 78 bridges to be built, at the intersections of the Queens Parkway system, as stated by Mr. Powell, a great variety of designs was called for. At the same time economy required as complete standardization of types as was practicable. Further, the character of the roads (parkways) called for especial attention to beauty of form and material. In a concluding article Mr. Powell will describe the general design and illustrate the appearance of the bridges on the new Queens Parkway system, the general plan and intersection designs for which have been described in this and a previous article. —EDITOR.

Lenticular Expansion Rollers for Concrete Spans

By Albert B. Willett

Associate Bridge Designing Engineer, California Highway Commission, Sacramento, Calif.

THE BRIDGE department of the division of highways, California state department of public works, has for the past several years used bronze expansion bearing plates under concrete deck-girder spans of less than 40 ft., and a cast-steel circular zone roller between two cast-steel plates embedded in the concrete for griders more than 40 ft. long. The writer, so far as he knows, originated the idea of substituting a lenticular-shaped roller for the circular zone-shaped roller. This type was first used in 1930 on three 60-ft. concrete deck-girder spans across the South Fork of the American River at Riverton, Calif., and has since been adopted as a standard by the California bridge department.

The following approximate formulas govern the action of the roller (Fig. 2) upon movement of the girder due to expansion or contraction:

$$(1) \qquad y = R - R\sqrt{R^2 - a^2}$$

$$(2) \qquad H = \frac{V \times a}{R + y}$$

in which H = horizontal force in the girder; V = vertical load on the roller; a = horizontal movement of the girder due to expansion of contraction; R = radius of roller; and y = distance girder is raised.

The approximation in the above equations is due to the assumption that the arc of the angle ϕ is equal to the horizontal movement a. The error involved is negligible for the range of movement involved in all ordinary structures.

On the South Fork bridge the total end shear in one girder of a 60-ft. span was about 117,000 lb. A rocker 6 in. high was used. Assume a movement due to a maximum drop in temperature of 40 deg. and, using coefficient of expansion of concrete as 0.000005.5, the maximum movement will be $60 \times 12 \times 0.000005.5 \times 40 = 0.1584$ in.

$$y = 6 - \sqrt{6^2 - .1584^2} = 0.0021 \text{ in.}$$

$$H = \frac{117{,}000 \times 0.1584}{6 + .0021} = 3{,}088 \text{ lb.}$$

This force of 3,088 will be the tension in the girder necessary to move the roller, neglecting rolling friction.

Expansion and contraction of the ordinary concrete deck-girder span,

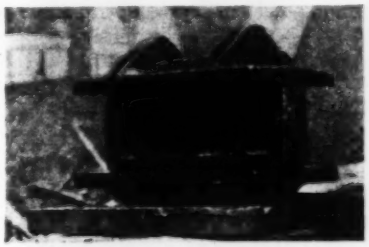

Fig. 1—Lenticular expansion roller used on concrete bridge over South Fork of the American River in California. Top and bottom bearing plates are keyed to roller by round keys.

which rarely exceeds 70 ft. in length, is comparatively small. When the girder expands or contracts from its original position the roller raises the girder a very slight amount and at the same time induces a couple, due to the fact that the points of contact of the plates with the roller are on the tangent of the curved surface of the roller and are therefore not in a vertical plane. This couple induces compression in the girder due to expansion, and tension due to contraction. These stresses are comparatively small.

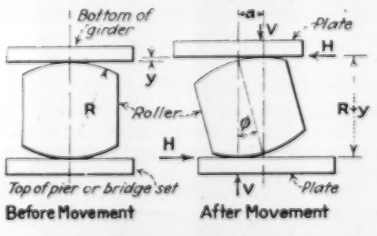

Fig. 2—Sketch showing action of lenticular roller under bridge movement.

The roller is designed with a bearing capacity per linear inch of roller of $600\,d$, where d is the theoretical diameter of roller. In manufacturing the roller it is first cast, then placed in a lathe or milling machine, and the two bearing surfaces are turned to the proper radius. Contact surfaces of the top and bottom plates are planed. Two round keys in both the top and bottom plates are used to hold the rollers in position and the girders in line laterally. Holes in the plates for these keys are bored for a driving fit. The holes in the roller are oversize to allow for a slight play due to the movement of the roller.

The roller is inherently stable and tends to remain in a position normal to the two plates, is positive in action and open to inspection at all times. Its reduction in height and width over a circular roller will reduce the cost about 50 per cent. Also it is more economical than bronze sliding plates and has eliminated much of the trouble previously experienced with expansion plates. These lenticular rollers have been used by the state under steel stringers and recently have been adopted by the U. S. Bureau of Public Roads in its typical plans for steel highway bridges of deck-truss and I-beam spans.

Canning Wastes Treated With Lime and Ferrous Sulphate

Recent experiments on industrial wastes by the Wisconsin state board of health have produced the following results: The application of 14 lb. of lime and 4½ lb. of ferrous sulphate per 1,000 gal. of the composite washer, peeler, blancher, capper and other wastes incident to the beet-canning process effected a reduction of 96 per cent in suspended solids and 50 per cent in five-day b.o.d. (biological oxygen demand) in a fill-and-draw type of chemical precipitation plant. In the treatment of carrot-canning wastes the use of 7½ lb. of lime and 3¼ lb. of ferrous sulphate per 1,000 gal. of the wastes effected a reduction of 98 per cent in suspended solids, and 67 per cent in five-day b.o.d., using the fill-and-draw process with a two-hour settling period of the treated wastes. Subsequently the wastes were pumped into the dosing tank of a trickling filter at the municipal sewage-treatment works. The effluent from the plant showed 82 p.p.m. total solids, 57 p.p.m. suspended solids and 88 p.p.m. 5-day b.o.d., which is entirely satisfactory for final disposal in the small stream available for dilution of the wastes.

Future Road Program Planned for Illinois

Higher standards of engineering administration and accomplishment set forth in a report to the state legislature by a commission on future road program

FOLLOWING a period during which one of the finest highway systems of any of the states has been built, Illinois has just had prepared a plan for future highway development. This plan was prepared by a legislative committee, since the 10,000-mile bond-issue system is 93 per cent complete and future development requires a reallocation of funds, which is a legislature task. The commission sought only to recommend for legislation "broad and flexible administrative policies which will safeguard the public interest and at the same time give free expression to highway administrators and engineers in meeting the ever-changing problems arising from the progress of time." Questions of road type, width, design, cost or other technical principles are not considered. Forty conclusions and recommendations are submitted, the essential features of which are now being translated into bills for submission at the present session of the legislature. The more pertinent of the conclusions are as follows:

The state bond-issue system should and can be completed in 1933 if present revenues are not disturbed. Principal and interest on existing bond issues must be met from motor license fees. Neither license fees nor gas tax should be reduced and fundamental economic law and fairness demand their use exclusively for roads. Adequate maintenance is essential to safeguard the original investment in highways.

As funds become available, needed refinements of the original system, such as grade separations, large bridges, correction of location and alignment, resurfacing and widening, should be completed.

Under a fundamental basic plan to be made effective by minor amendments to existing law, additions to the state bond issue or primary system are to be made only under provisions of the federal highway act, which permits extensions progressively in a rational manner with adequate safeguards as funds become available. When such needs are met, secondary roads may be improved with the funds released. Secondary roads should be improved by the counties. Third-class or township roads, in the construction of which there is grave need for increased efficiency and economy, should be cared for by the county, a referendum to be held eliminating the township as a road-taxing and administrative unit. Elimination will reduce direct taxes and special assessments by $15,000,000 annually.

Roads through municipalities should be built without restriction as to type and width, funds being allocated on the basis of population.

The highway program is one of the most stabilizing influences in the economic structure, lightening the relief burden. Hence no moratorium on road-building should be considered.

Technical requirements for county highway superintendents should be more rigid, and two or more counties should use the same superintendent.

Traffic and economic studies and traffic regulations should be continued. Road signs and signals should be uniform and adequate appropriation should be provided. Advertising signs within 1,000 ft. should be regulated and taxed.

Study should be made of stricter regulation of buses and trucks, and fees should be larger.

Railroad grade-crossing elimination should be continued under policies relating to cost division that will be equitable and productive of prompt execution. Crossings should be protected by adequate and uniform signs upon order of the commerce commission. Present obsolete signs prescribed by statute should be eliminated. The commission should be given authority to order removal of obsolete car tracks and the paving of car-track areas.

The building of setback lines should be legalized to facilitate the future acquisition of needed rights-of-way. Cemetery property should be made subject to condemnation.

Engineering policies should not be subjects of legislation, or else engineering initiative and advancement will be stifled. All highway funds should be allocated in accordance with economic facts and traffic needs. Only basic legislation predicated on these studies is recommended.

Highway revenues hereafter should be allocated as follows: Motor license fees should pay bond service first, then maintenance and policing of highway, then construction or reconstruction of bond issue and federal-aid roads, and finally refunds to counties for roads built in anticipation of state aid. For the 3-c. gas tax the following allocation is recommended: one-third to the state for new construction on the primary system, one-third to the state for expenditure within cities on arterial routes, and one-third to the counties.

Coordinated planning by state, county and city in the Chicago and other metropolitan areas is recommended. In this connection there has just appeared a report by the committee on traffic and public safety of the Chicago city council on "limited ways" for the greater Chicago traffic area, being a recommendation for the construction of three elevated highways within the city. Governor Henry Horner has initiated a move looking toward a board made up of state, county and city representatives to prepare a metropolitan program. If preliminary cooperation can be effected and legislation passed, appropriations can be made available by July 1. This is a $17,500,000 project, to be paid for out of gas tax allotment.

For the other recommendations of the state advisory commission bills are being drawn and will be acted on by the sitting legislature.

Coast-Survey Work in Oregon

A new arc of triangulation extending from Pendleton southwest to Crater Lake, Ore., which will establish triangulation stations or points of orientation at 10-mile intervals for the accurate determination of boundary lines and other engineering operations, has just been started at Pendleton, Ore., according to R. S. Patton, director, Coast and Geodetic Survey of the Commerce Department. The arc will pass through Umatilla, Morrow, Wheeler, Crook, Deschutes, Lake and Klamath Counties.

This work constitutes an important link in the federal government's project of triangulation and leveling authorized by Congress, which will eventually result in the accurate measurement of distance and the placement of triangulation stations and benchmarks within 25 miles of every place in the United States.

While of a highly technical nature, this work is of inestimable value when adjusted into the national triangulation system, and the practical dollars and cents benefits of the project to every citizen in every state cannot be overestimated, according to Captain Patton.

The measurements fixed and the subsequent establishment of triangulation or control stations furnish a strong control for city, county, state and federal surveys and maps, for the location of boundary lines of all kinds, the planning of roads—in fact, all purposes where a knowledge of location, distance and direction are needed in engineering.

Each triangulation station is marked in a permanent manner with a block of concrete into which is set an inscribed metal tablet. Church spires, cupolas, water towers, airway beacons and chimneys are located and tied in during the progress of the triangulation work.

Tractors Used to Break Trails for Brush-Fire Protection

FOR fire protection and trail-breaking on the brush-covered hills behind Los Angeles, the municipal fire department operates fire-fighting equipment consisting of tractor-trailer units carrying 1,000-gal. tanks and pumps. Routine work for the equipment includes clearing firebreaks and building trails with bulldozer equipment or replenishing water-storage tanks in the area. In case of fire the units are mounted on wheeled trailers drawn by high-powered fire trucks and rushed by highway to the nearest point of attack.

In otherwise inaccessible area, tractor units break trails, build fire breaks and transport water tanks and pumping equipment when fires break out.

Extending in a rough semicircle behind Los Angeles is an area of rugged terrain, uninhabited and covered with a brush growth which is a serious fire hazard during the dry season. This territory, which is within the city's boundary, is 30 miles long and averages about 3 miles wide. Along the city side it is paralleled by adequate highways, but the hills are practically inaccessible for wheeled vehicles.

As a fire-protection measure, water pipes have been laid through a part of this area, and the rest is provided with 3,000-gal. steel tanks located at strategic points and kept filled with water. In case of fire the tanks are used to fill the 1,000-gal. tanks on the trailers, which are connected to pumps throwing about 300 g.p.m., driven by auxiliary motors.

The tractors are standard units similar to pieces of construction equipment and are equipped with bulldozers for cutting firebreaks, rooting out brush and building trails.

Letters to the Editor

The Use of Hooping in Heavily Reinforced Columns

Sir—In the article "Concrete Columns With Large Bars Offer Advantages" (*ENR*, Sept. 8, 1932, p. 277), T. Germundsson shows by precise calculation the economic advantage of using longitudinal reinforcing to an amount far beyond the limits of American (and also German) rules of practice. While this advantage is most remarkable, no explanation is given as to why the author assumes an amount of hooping only one-sixth the longitudinal reinforcement, although a given amount of steel is more effective in the form of hooping than in the form of longitudinal reinforcement. The following attempts to show how the column discussed in the article cited would be proportioned according to the 1932 specifications of the Deutsche Ausschuss für Eisenbeton (German Reinforced Concrete Committee).

The carrying capacity of a hooped column is found from the following formula, which holds for f_c' not less than 2,270 lb. per sq.in.:

Allowable load
$= \frac{1}{3}\,(K_b F_k + f_s F_s + 2.5\, f_s' F_s) = \frac{1}{3}\, K_b F_i$

in which

$$F_{is} = F_k + \frac{f_s}{K_b} F_s + 2.5\,\frac{f'_s}{K_b} F_s$$

Whence allowable core stress
$= \frac{1}{3}\,(K_b + p\, f_s + 2.5\, p_s f'_s)$

In these expressions K_b represents the 90-day prism strength of the concrete in the columns, in place of which the cube crushing strength at 28 days may in general be used but not more than 2,550 lb. per sq.in. Under certain conditions this value may be exceeded, but the matter does not affect the present instance, since $f_c' = 2{,}500$.

F_k = cross-section of core $= \frac{1}{4}\pi D^2$

F_s = cross-section of longitudinal reinforcement

$p = \dfrac{F_s}{F_k}$

F_s = amount of hooping, calculated as longitudinal steel

$p_s = \dfrac{F_s}{F_k}$

f_s = longitudinal steel compressive stress at plastic limit

f'_s = hooping tensile stress at the yield point

The latter two values may be taken as 34,000 and 46,600 lb. per sq.in. in the case of the commercial bar steel current in Germany.

Thus, p_s is 3.43 times as effective as p. Excessive hooping is limited by the fact that the longitudinal steel must not be less than one-third the equivalent of the hooping steel and that F_{is} must not be greater than $2F_i$ in which $F_i = F_b + f_s \dfrac{F_c}{K_b}$ where F_b is the full concrete cross-section.

The maximum percentage of longitudinal reinforcement is fixed at 8, while the corresponding maximum value of spiral reinforcement is largely influenced by the ratio of total concrete section to core section. In the case of the column in question, with longitudinal steel percentage 12.7, the ratio of total section to core section is 1.82. Retaining these cross-sections of concrete and of core, and with $f_c' = 2{,}500$ lb. per sq.in., the load capacity of 1,150,000 lb. may be obtained according to the German specifications by making the percentage of longitudinal steel 2.16 and the hooping percentage 6.48.

This is the most favorable proportion of reinforcement, in which the longitudinal reinforcement is one-third the equivalent hooping section, and the sum of the steel amounts becomes a minimum, with 8.64 per cent in place of

Mr. Germundsson's 14.67 per cent. If the longitudinal reinforcement were increased to the permissible maximum (of the German specifications) of 8 per cent, the hooping would still amount to 4.98 per cent, making the sum of the two steel percentages 12.98 per cent. With increased amounts of longitudinal steel beyond the range of validity of the specifications, up to the amount adopted by Mr. Germundsson, of 12.7 per cent, the hooping percentage would become 3.41 per cent and the sum of the two percentages 16.1 per cent, although it should be remarked that the formula may not be used beyond 8 per cent.

From the preceding figures it is permissible to conclude that on the assumption of equal strength of material and equal form of columns it would have been more advantageous to proportion the column with less longitudinal steel and heavier hooping. A second conclusion is that the concrete dimensions can be decreased. Approximating the permissible upper limit of longitudinal reinforcement of 8 per cent, with 2 in. of concrete cover the outside dimensions of the columns would become 21x21 in. and the core diameter 17 in. (against the author's 24x24 in. and core diameter of 20 in.), with longitudinal steel of 7.92 per cent and spiral steel of 8.53 per cent. It should further be remarked that in spite of the increase in total steel to 16.45 per cent against 14.67 in the Germundsson column, the actual weight of steel is reduced by 19.3 per cent, since the percentage applies to a smaller cross-section of column. This cross-section is just about as large as that required for the incasement of a steel column. Further increase of concrete strength and use of high-strength steel would enable the concrete cross-section to be decreased still further.

Darmstadt, Germany, Nov. 9, 1932. K. HAJNAL-KONYI.

Limit Competitive Bidding

Sir—A careful individual who believes in conserving the physical assets of his own body subjects himself periodically to a thorough examination by his family physician. This procedure results not only in checking deteriorations that may have begun, but it also serves to prevent the development of possible infection or disease.

These days of stress and strain might well present a splendid opportunity for such an examination of the building-construction industry, which to many has every appearance of having come upon evil days.

Aside from the fact that lack of free capital, overproduction and other factors may be cited as causes for the depressed state of building construction, there are certain inherent features which have been part and parcel of the business and which must be altered if the industry is to assume a respected status in our economic life.

To the writer it appears to be of prime importance that so-called free engineering and architectural services rendered by vendors of building materials and building specialties be eliminated.

This proposal applies to those who furnish free plans with the purchase of materials, to architects who furnish free of any charge sketches for proposed construction, much of which never reaches the preliminary estimate stage and in too many cases is utilized by the owner as a means of selling unimproved property.

The writer, for example, has received offers of free trucking service for his construction equipment to go with the purchase of a given material. The economic waste of such a policy, if not immediately apparent, is nevertheless accumulative and must result eventually in a chaotic market.

The most glaring abuse appears, however, to be in the unlimited number of competitive bidders that are permitted to submit proposals on a single project. Especially is this true of government work, federal, state and municipal. To a large extent, the well-established architects have rightly restricted the bidding to a selected list. But there are still too many cases where 40 bidders may be invited to bid upon a $10,000 building alteration, and it is not unusual to find that the total cost of estimating for all bidders on a given project exceeds the estimated profit of the successful contractor.

It appears to the writer that the time is not far off when building construction will take its place among the professions; when a license to practice in this field will be as necessary as it is in the professions of law or medicine. To prepare for that eventuality, the industry should begin now to purge itself of those practices which, under the new scheme of things, will become unlawful, and which at present must certainly be considered unethical.

New York, N. Y., Jan. 12, 1933. JAC C. HOLMAN, Holman Construction Co.

Concerning Vertical Curves

Sir—The article on "Vertical Curves for Highway Grades" by M. W. Furr (*ENR*, Oct. 27, 1932, p. 496) brought to my mind a table of offsets to vertical curves which I had drawn up for the use of inexperienced field men, from which the offset to the vertical curve at any distance from the point of tangency, for any rate of grade change per station, could be easily determined by a simple ratio.

Most textbooks and handbooks begin and end their vertical curves at "even stations" in their demonstrations and examples, whereas in practice the vertical curve most frequently begins and ends at a "plus point," which necessitates the squaring of large numbers. Here is where most of the errors occur.

The table of offsets, beside readily securing the offset by means of a co-efficient, has other uses, among which is the selection of the proper vertical curve to use to avoid excessive cut or fill at the center of the curve. I have never seen anything that even faintly resembles it and have found it a great time-saver in many ways.

Cleveland, Ohio, Jan. 9, 1933. HOWARD L. SMYTHE.

* * *

Sir—In your issue of Dec. 22, 1932, there was printed a letter on "Parabolic Vertical Curves" by A. D. Millard. The writer certainly agrees with everything Mr. Millard had to say in regard to the present practice of highway grade location.

In a discussion of Gilchrist's paper on "Highway Location: General Considerations" (*Trans.*, Am.Soc.C.E., Vol. 96, p. 63) the writer made similar commentaries on the subject of frequent grade reversals.

The argument advanced by highway engineers that momentum grades are justified due to free wheeling in automotive traffic is not tenable since it is frequently necessary to brake automobiles going downhill, and to de-accelerate going uphill due to heavy traffic and short sighting distances over hills.

The writer cannot agree with the old slogan that "Railroad engineers make poor highway locating engineers." The best mountain highways in Colorado are the reconverted railroads such as the Cripple Creek Short Line in which a $1 toll per person is charged. A ride over the road is well worth the toll charge from an economic standpoint.

The reason for the present policy of grade location is that the governmental state aid sets definite rules and requirements before financial cooperation will be granted. Those rules are not sufficiently elastic to permit of a resident or locating engineer exercising his better judgment, and as a consequence the rules are followed to the letter and personal initiative is destroyed. The writer has observed that standard plans for bridge abutments and culverts seem to be all reinforced for the worst possible conditions of soft-soil foundation, and that the same reinforcing is used on hard soil where definite economy would indicate lighter reinforcing.

No changes may be expected in this practice until the locating and resident engineers are given more latitude to exercise individual judgment. In New Mexico, where the recently constructed mountain highways have excellent grades and where the most has been made of local materials for construction, the engineers have been privileged to use their native ability and sense of fitness to design and construct highways from practical considerations.

The state and federal highway over Berthoud Pass in Colorado is a brilliant

exception to the above criticism. It is unusually well engineered; on this location there are a minimum of grade reversals, and the utmost utility has been attained by the use of local granite in the construction of retaining walls and drainage structures.

Tyler, Tex., Jan. 15, 1933. H. L. THACKWELL, Consulting Engineer.

* * *

Sir—The article on "Parabolic Vertical Curves for Highway Grades" (*ENR*, Oct. 27, 1932) and the companion articles in the issues of May 20 and Aug. 12, 1926, are perhaps worth a little further consideration.

In projecting *horizontal alignment* the constant effort is to fit the topography. In so doing, the minimum radius of curvature, whether adopted arbitrarily or computed for an assumed sight distance, is used only where it is imperative to do so. Wherever possible flatter curves are always employed so that the combination of curves and tangents will best fit the ground.

The establishment of grades or, more correctly, the projection of *vertical alignment* should be done in exactly the same way. Tangent grades and vertical curves should be studied together so as to fit the ground best. The minimum vertical curve as computed for a given sight distance should be used only when it is impossible to secure a curve of greater length. Altogether too frequently the tangent grades are set and arbitrary vertical curves inserted with utter disregard of whether the combination fits the topography or not. Many highway grade lines could be improved in appearance, riding qualities and safety by the use of longer vertical curves, and generally with an accompanying saving in earthwork.

In the early days of railroad location men capable of computing the various problems were few and far between. It was necessary, therefore, to prepare tables, formulas and charts so that men with inadequate training could do much of the work. Today college-trained men are readily available in either highway or railway work, so that the need for tabulation, etc., has largely disappeared. Dependence on tables or fixed formulas should, therefore, be avoided, since there is always a decided tendency to use such stuff in place of analyzing the immediate problem.

The great danger lies in the fact that such material frequently becomes obsolete due to changed conditions. Many poor layouts can be traced to the use of antiquated tabular material or to equations containing specific but out-of-date constants. For example, the formulas and tables in the article of May 20, 1926, have already been outgrown, as witnessed by the fact that they have been revised or replaced by those of the latest article, and there is no assurance but that these latter may need changing in a few years.

The templet described in the first article is in itself correct, but it should be distinctly remembered that it gives only one specific curve, which may or may not be the one desired. This templet's place in the drawing kit is exactly analagous to the curve ruler of minimum horizontal curvature. Moreover, vertical curves are so easily spotted on profile paper that it is a question whether it is worth while to bother with parabolic templets.

The nomograph described in the article of Aug. 12, 1926, is an interesting toy but of little practical value. It is too complicated for the simple problem that it has to solve. It would probably require more time to find it and to remember how to use it than to solve the problem directly with the ubiquitous and ever-faithful "slip stick."

Credit, however, is apparently due Professor Furr for the first publication of a formula for the length of a vertical curve when the total grade change is such that the actual length of curve is theoretically less than the assumed sight distance. This is his equation 11, but it is unfortunate that he did not put it in its general form:

$$L = 2l - \frac{8h}{K}$$

instead of assigning a definite value of 5 to the height of the line of sight h. There is no assurance that changes in road speeds or vehicle designs may not require a change in the value of h.

The practical use of this equation is open to question. It is quite obvious that the required length of curve L given by it becomes 0 when the total grade change K equals $\frac{8h}{2}$, and that for smaller changes of grade it gives negative values of L. For example, if $h = 5$ ft. and $l = 5$ sta., L becomes 0 when the total grade change K equals 4 per cent. Certainly no one would tolerate a grade change of 4 per cent without a vertical curve despite the fact that the assumed sight distance requires none. Again, if $h = 5$ ft. and $K = 2$ per cent, L becomes —10. And who knows just what this means?

If the general equation is used for length of curve based on sight distance (equation 7)

$$L = \frac{l^2 K}{8h}$$

when L is theoretically less than l, there will be obtained the arc of a parabola that will properly connect the two tangent grades and be of such character that if extended to the length l, the offsets from the ends of the tangent at its middle would equal h. In other words, it is an arc of the parabola of minimum *rate of change* for the given sight distance. Furthermore it is evident that with this equation L becomes 0 only when K becomes 0; hence it will always provide some finite length of curve, and therefore its use is better practice than the use of Eq. 7.

But again, it should be remembered that these equations give merely the *safe minimum* length of curve, while the topography may and usually does demand or permit the use of longer curves. The proper method is to select a curve to fit the ground and then test it to see that it gives adequate sight distance. A table giving the minimum permissible length for various grade changes might be useful for quick checking, but such tabular values should not be taken as standards for normal use.

C. C. WILEY, Associate Professor of Highway Engineering, University of Illinois. Urbana, Ill., Jan. 11, 1933.

Earthquake-Proof Joints

Sir—A number of points interested us in the article "Welded Joints for Seismic Stresses in a Tall Building," by Mr. H. H. Tracy (*ENR*, Sept. 15, 1932, p. 312). Mr. Tracy states in the first paragraph of the article: "Although several buildings in Japan had been designed to resist seismic stresses, they were not more than six stories in height and therefore not comparable to the thirteen-story Edison building." In the Mitsui building, Tokyo, a five-story building designed by us and probably one that the author had in mind (*ENR*, June 23, 1927), there occurred some very large bending moments in columns and girders, due to a 42-ft. 6-in. story height between the first and second floors. The moment between the member (a double truss connecting to one side a column at the first floor) was 938,000 ft.-lb. for an interior and 1,876,000 ft.-lb. for an exterior column, compared to a moment "in excess of 600,000 ft.-lb." mentioned by Mr. Tracy. According to the Japanese law, it was necessary to use a fiber stress of 16,000 lb. per sq.in. in resisting these moments.

Mr. Tracy also speaks of the compactness of the welded connections and the space saved over what might have been used in a riveted design. It should be borne in mind that to resist earthquake shock a steel frame should not only be strong enough to withstand being demolished; it must also avoid such excessive deflection as might crack and shake loose the masonry walls and floors. From this viewpoint the problem is analogous to that of wind on high buildings. In the past some rather high structures have been built which, while probably quite safe against being blown over by a high wind, sway so as to cause cracks and an unpleasant sensation. The fault has been in squeezing the structural requirements too far. Granting that the same strength can be obtained in a connection in less space and that shallower members can be employed in a welded design than in a riveted one, care should be taken, regardless of the type of connections, to obtain a structure of sufficient rigidity.

WEISKOPF & PICKWORTH, Consulting Engineers. New York, N. Y., Nov. 22, 1932.

Engineering News-Record

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Editorial and Publishing Offices at 330 West 42d St., New York; 520 North Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, London, England.

Subscription price $5 per year in the United States; foreign rates on application.

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FEBRUARY 23, 1933 Volume 110 No. 8

Support the Wagner Bill!

Amendments to the Relief Act designed to make it effective in re-creating employment are now before Congress. They ought to be passed before the present session expires. Every engineer, every member of the construction industry throughout the country, in fact every citizen concerned in business recovery and public welfare, should help to assure their enactment by urging his representatives in Congress to vote for the Wagner Bill. The purport of the amendments has already been reported (*ENR*, Feb. 16, p. 233). By extending the scope of loans to public projects that are "needful and in the public interest" (instead of "self-liquidating"), by reducing interest rates to not more than one per cent above that of government bonds, and by striking out the words that forbid dependence on tax revenues for repayment of the loan, the Wagner Bill proposes to relieve the unworkable rigidity of the present act and to remove occasion for the fine-spun interpretations by which the R.F.C. made the act still more unworkable. There is enough proof of the ineffectiveness of the act as passed and administered—in the pitifully small number of projects approved, in the long delays before approval was given, in the failure to bring about any increase of employment. The bill has passed the Senate; it needs active support in the House!

Cities Are Not Extravagant

After exhaustive study of the financial and administrative practices of the town government, a citizen's committee of Montclair, N. J., has presented its report of recommended economies, which was abstracted briefly in our issue of Feb. 9, p. 204. Two features of the report are significant. First, the members of the committee state that they find no graft or unethical practices. Second, their recommendations for improvements in economical administration are such as might wisely be followed by any private business. They consist largely of proposals for reform in detail procedure by which a number of minor wastes can be eliminated and in the aggregate a substantial saving achieved. The report contains no dramatic revelations of gross extravagance. No single action has been discovered that would at one stroke solve the economy problem. This is a gratifying finding, for there is little reason to assume that Montclair is unique in this regard. Without doubt similar conditions would be disclosed in hundreds of other municipalities, if sincere and competent studies were to be made. Economy in city government can be achieved through cooperation between citizen and official, but the headlong indictment of all municipalities as extravagant and corrupt is not well designed to bring it about. So many irresponsible allegations of municipal corruption and incompetence have been made and so much has been said of their relation to municipal costs that it is a pleasure to study the report of a serious-minded committee that got down to earth.

Diversion of Water Funds

Strange to say, some of the groups intent upon reducing taxes and public debt are giving municipal water departments strong reasons for getting into debt and staying there. It has been quite common in the past year or so for water department net earnings to be diverted to general city purposes in an effort to reduce taxes. Many water department administrators have looked forward to the time when bonded debt will have been paid off and system improvements can be made at a measured pace out of annual net earnings. But they are now seeing their carefully gathered cash resources taken from them to support other city functions. They feel they cannot be assured that their yearly net will be available to them when they want to use it. Of what use under such conditions is conscientious financial planning? It will not be surprising if water departments attempt to conserve their revenue for their own uses by spending it before they receive it. They may very well decide that only by being constantly in debt for existing improvements can they be sure that their engineering planning will be carried out. Is this the end intended by the tax-reduction groups? Is it the best way to serve the public interest? We doubt it.

Construction in Canada

United action by many unrelated organizations representing the construction industry in Canada was noted in our news pages last week. This action is similar to that taken in this country at the highway and building congress in Detroit in January. It indicates that our neighbors in Canada are up against conditions very similar to those that are tending to disrupt the construction industry here, and that they are finding it necessary to bring the scattered elements of the industry together if its possibilities for forceful action are to be realized. Immediate action is to be directed toward the establishment of a national body corresponding to the Reconstruction Finance Corporation, through which both public and private construction work can be financed either by direct federal loans or through the support of federal credit. Direct relief for unemployment is to be opposed as leading to bankruptcy of the country. The construction industry of Canada is to be congratulated on this advance toward united action.

Again the Time of Mixing

General acceptance of the theory that prolonged mixing gives a superior concrete is apt to receive a definite setback from the analysis presented by Major Besson in our issue of Feb. 9, p. 183. The strength-increasing value of a mixing period of more than a minute is questioned as unproved by previous tests and is squarely contradicted by the special tests carried out on concrete dam construction in the Nashville engineer district. It is not to be expected that the review and interpretation of mixing-time test results will be generally assented to, but they indicate that current faith in the virtue of an over-a-minute mix is at least assailable. It is certain also that the assailants will find supporters. A vital production problem is involved in over-a-minute mixing that cannot be ignored in

these days of high-speed and large volume concrete construction. If high production is to be maintained with long mixing periods, a new development in mixer equipment is portended. Major Besson's discussion opens a question that ought to have a conclusive answer soon.

Rail Transit Problems

FUNDAMENTAL facts bearing on our present-day transportation problems, especially upon those of the railroads, are clearly set forth in the report of the National Transportation Committee made public last week. Prepared on the initiative of large holders of railroad bonds, the report is peculiarly significant in its frank statement that these bonds have no special claim to preference over any other private investment. "The public interest is deeper than its investment," says the report, hence the investment must not be protected by handicapping the newer forms of transportation and thus depriving the whole nation of the advantages to be derived from them. The nation's concern should be only to see that all forms of transportation are treated alike, none favored at the expense of the others, but with such coordination as efficient transport demands.

Needed remedial measures are outlined by the committee. A summary of them is given in the news pages of this issue. With one possible exception they have been made before, some of them repeatedly. Many of them were included in the unofficial but highly significant agreement between highway users and railroad executives made public a fortnight ago.

The exception noted among the recommendations is that of basing railroad rates (where not controlled by competition) on the cost of efficient service rather than on the value of the property dedicated to the transportation service, a recommendation that implies scrapping much of the valuation work done to date. If a railroad cannot earn enough to support its capital structure on that basis, says the committee, the remedy is not to be found in raising rates but in revising the capital structure. This whole proposal is one that seems to involve serious difficulties in application.

Aside from this major point and one or two minor ones, the report contains little original thought. It is rather a well-organized summing up of progressive thinking on railroad and general transportation problems. Such was to be expected from men none of whom is a student of railroad problems. It is to their credit that they attempted to sift the best out of available studies rather than to develop new theories in the brief time at their disposal. As a consequence, the significance of the report lies not in the novelty of its substance but in the force that is added to the conclusions restated therein. To those who set up the committee the report says in no uncertain tones that their vast holdings of railroad securities are not exempt from sacrifice upon the altar of progress or of poor management. To legislators it says that the chaotic condition of our transportation system is due in no small part to their lack of vision and adherence to tradition. To the railroad managers its message is equally definite: "Many of your troubles are of your own making. Do not expect the public to bear the cost of your mistakes."

Unofficial though this report is, public confidence in the men who made it is sure to give it a wide hearing. It may well develop that it marks the turning point of our system of transport regulation.

Beware of Silicosis

SILICOSIS, a lung disease long known to the medical profession and the scourge of many mining districts, threatens to become a serious problem to the construction industry. In the face of this threat it is well for construction to recognize the situation and take the necessary steps for protection. Contractors are wholly unprepared to cope with the menace, yet the workman is entitled to be guarded against the destructive health hazard, whose magnitude is witnessed by a list of silicosis damage suits, filed against a single tunnel contractor, aggregating one and one-half million dollars.

Silicosis is a fibrosis of the lungs caused by exposure to silica dust. Ordinary dust particles can be thrown off or otherwise taken care of by the human respiratory system, but the sharp particles of silica dust cut through the lung tissue and set up a condition against which medical science is almost helpless. The disease usually does not show its effects immediately after exposure, but may appear years afterward.

In the fight against silicosis, the first and most important weapon is caution on the job, which is the source of infection. The selection of workmen should include X-ray examination of every applicant, to detect those already afflicted, who are obviously unfitted for further work in silica rock. The next precaution is to keep the silica dust out of the lungs, either by catching the dust at its source at the drill-hole or by equipping the workers with adequate masks.

According to medical authorities who have studied the recent history of the disease, a dust trap developed in this country last year, which collects the deleterious dust at the drill-hole, is the most efficient yet devised. Wet drilling, once regarded as an ideal protection against all rock-dust troubles, is now rated ineffective in catching the dangerous silica particles. Ordinary masks are likewise ineffective in keeping the silica dust out of the lungs. A positive-air mask, in which a fresh supply of air is supplied from an outside source, is essential if the mask type of protection is to be used.

Silicosis is recognized as a compensable disease in only one or two states; it should be so recognized in every state. Until then the contractor will be at the uncertain mercy of the courts in settling damage suits. It is desirable also that the law should state how silica dust is to be controlled and should distinguish between silicosis and ordinary respiratory diseases. An example of what not to do is presented by a bill recently introduced in one of the state legislatures, which though intended to deal with silicosis, uses the term "pneumoconiosis," under which term, medical men say, a contractor might be liable for any respiratory disease, including pneumonia. Because of the danger of such confusion under any law, moreover, the review of silicosis cases should be entrusted only to the hands of a competent medical board.

It is apparent that in the threat of silicosis the construction industry is facing a new and wholly unfamiliar problem, and one whose satisfactory solution depends on intelligent action. Labor organizations and legislatures already have taken the problem in hand; contractors should cooperate heartily. If they ignore or fight the effort to bring silicosis into recognition, they may soon find themselves in a bad situation. But if they recognize the problem and give the time and effort necessary to its sane solution, the specter of silicosis can soon be banished.

NEWS OF THE WEEK

Rail Problems and Aid Outlined in Committee Report

REASONS for the present difficulties of the railroads and measures which should be taken to correct them are outlined in the report of the National Transportation Committee made public on Feb. 15. The committee was set up by a large group of insurance companies, extensive holders of railroad bonds. Columbia University, Harvard College, Yale University and the University of Chicago also joined in setting up the committee. It consisted of the late Calvin Coolidge, Alfred E. Smith, Bernard M. Baruch, Clark Howell and Alexander Legge. This committee chose Harold G. Moulton of the Brookings Institution, Washington, D. C., to take charge of its research activities.

The report issued Feb. 15 consisted of a series of conclusions, reproduced below, with explanatory statements appended to each. It was signed by three of the surviving members of the original committee. A supplementary statement by Alfred E. Smith supported most of the conclusions of the other members of the committee but did not favor a single nation-wide railroad system, as tentatively proposed by them, nor their proposed change in the rate-making system. Also, Mr. Smith advocated reducing the Interstate Commerce Commission to one man with elimination of most of the commission's present functions.

Transportation committee conclusions

I. The railroad system must be preserved. Changed conditions require new policies, but not abandonment of railroad regulation. The development of regulation and of new methods of transport make it unnecessary for government further to create and foster competition with or among railroads as a defense against monopoly. That is an expensive and ineffective attempt to do indirectly what government has shown its ability to do directly. Regulation is sufficient. Government policies should be freed of any purpose either to favor or to handicap any form of transportation with relation to any other form. We cannot solve the problem on the theory upon which horses are handicapped in a race. In a fair field and no favor competition should be permitted to decide the result. Regulation should not attempt to "run the business" of transportation. It should concentrate on protecting the public against discrimination and extortion and on requiring the most efficient service at the lowest competitive cost.

(1) Parallel lines and systems are wasteful and unnecessary. Regional consolidations should be hastened and, where necessary, enforced, looking eventually to a single national system with regional divisions and the elimination of all excess and obsolete lines and equipment. Neither

(Continued on p. 265)

Allocation of Colorado Water to State of Arizona Formulated

A proposed contract between the federal government and the state of Arizona whereby at least 2,800,000 acre-feet of the water stored in the Hoover Dam reservoir would be allocated to Arizona was announced by the Secretary of the Interior on Feb. 13. To date, negotiations between Arizona and California for an allocation of the main-stream water below the dam have been unsuccessful. In negotiations with other states Arizona has insisted upon receiving 2,800,000 acre-feet of main stream water plus one-half of any excess. In the proposal now put forward by the Department of the Interior Arizona and the United States would be the sole parties to the contract. The statement by Secretary Wilbur regarding the contract follows:

The proposed contract would be an undertaking by the United States to deliver from Hoover Dam enough water each year to enable total mainstream uses in Arizona of 2,800,000 acre-feet, leaving without prejudice and to future negotiations the disposition of any water available in excess of that amount. In the form of a water delivery contract, this agreement would parallel generally the water contracts previously made or approved by the Secretary between the United States and California interests. The proposed contract recites the existence of a controversy between Arizona and the other States over the proper construction of the Colorado River compact and the Boulder Canyon Project Act, and as to how much water is available to Arizona under the various classifications made by the compact. It leaves these questions of priorities to future agreement or adjudication, assuring Arizona the delivery of a total amount of water, but without assigning its relative priorities.

Hoover Dam, the construction of which was authorized after the Colorado River Compact was executed, has introduced an entirely new factor in the apportionment of waters in the lower Colorado basin. It will provide about 30,000,000 acre-feet of storage, or two years' flow of the river. This makes it possible to arrange for this distribution of water at the present time

Engineers Work on Regional Map as a Relief Measure

Unemployed engineers in the region around Rochester, N. Y., are being given work by the Monroe County Emergency Relief Committee in the preparation of a map for the Regional Planning Board. Thirty civil engineers and statisticians are engaged on the work.

Highway Economics Stressed at Northeastern States Road Meeting

HIGHWAY ECONOMICS was the leading topic discussed at the three-day session of the ninth annual convention of the Association of State Highway Officials of the North Atlantic States held at Atlantic City Feb. 15-17. In addition, some twenty papers were presented on the technique of highway biulding, maintenance and operation. At the opening session, L. D. Barrows, president of the association, sounded a note of warning of the dangers confronting the highway industry in curtailment, diversion and, in some cases, complete stoppage of road funds. Several speakers urged the continuation of federal aid. A resolution adopted by the convention also called for a continuation of federal aid, pointing out that with the federal gas, oil and tire taxes now in effect, the motorists of the country are paying into the federal treasury an amount far exceeding the federal aid appropriations.

Protection of the capital investment of our highways, the welding of all roads into a national system of transportation, and abandonment of the hand-labor fallacy were called for by W. T. Chevalier, publishing director of *Engineering News-Record*, in an address at the opening session. He pointed out that for years our highway problem was one of providing more and better-built roads. Technical features of design and construction were paramount. Now the picture has changed to one of economics. Our vast highway investment is in jeopardy unless steps are taken for its protection. Demands of both uninformed and selfish interests for curtailment and diversion of highway funds are being thrown at state legislatures and at Congress from all sides. Col. Chevalier maintained that a tremendous waste in operation of our many governmental agencies should be made to meet the demands for public economies rather than a curtailment of road activities.

Col. Chevalier also pleaded for an abandonment of the hand-labor policy in highway building, except where such practice can be carried out at somewhere near the cost of machine operation. Both he and Jacob L. Bauer of the New Jersey highway commission reminded the convention that our present system of roads has been made possible only by the efficient and economical construction provided by highly-developed machines.

The low-cost road program of Pennsylvania, as advocated by Gov. Pinchot, was described by S. S. Lewis, Secretary of Highways. The program was presented as one not only designed to take the rural areas out of the mud, but to foster dis-

persion of present excess population from industrial centers back to the land, where a proportion of it must go. The speaker stated that the return to the land movement did not necessarily mean a return to actual farming in every case, but it did mean the providing of rural roads necessary for the further development of small towns with accompanying industries. Rural road development must be done on a basis of economics. As such it is necessary to make up a budget at least ten years in advance to provide for proper expansion of the road system. An average cost of saving of operation of a motor vehicle on improved roads over unimproved highways is estimated at 2.2 cents per mile per vehicle. A traffic survey and traffic estimates, based on this figure, will determine the amount of expenditures warranted in the development of any road.

Low cost roads

The construction of low-cost roads was the subject of several papers. William McWilliams of the Delaware state highway department discussed that state's construction of 9-ft. concrete roads and traffic-bound macadam roads. Gravel construction was the subject of papers by E. E. Reed, New Jersey, and Charles B. Bryant, Maryland. A. W. Bushell, Connecticut, told of his state's experience in building macadam roads of native stone and trap rock. The revived practice of cement-bound macadam road construction was discussed by George L. Nickerson, of New York, in a paper describing the recently-completed section of road of this type near Newburgh, N. Y. Bituminous road construction practices were the subjects of papers by E. C. Lawton, New York, who spoke on "Re-treads"; H. E. Sargent, Vermont, "Mixed-in-Place"; R. W. Coburn, Massachusetts, "Penetration Macadam at Low Cost"; E. L. Merrill, Maine, "Light Bituminous Resurfacing Over Surface-Treated Gravel"; and A. R. Taylor, engineer, Koppers Products Co., Pittsburgh, "Development of Low-Cost Tar Surfacing." The characteristics of various asphaltic road materials were described by Prevost Hubbard, chemical engineer, The Asphalt Institute.

New developments in the production and use of brick pavements were described by G. F. Schlesinger of the National Paving Brick Association. Three recent developments in this line are the adoption of a protective coat over the brick surface to facilitate removal of excess bituminous filler, the manufacture of vertical-fibre wire-cut brick and the deaeration process of brick manufacture.

Special equipment for concrete paving construction was the subject of three papers by E. H. Lichtenberg of the Koehring Co., Fred C. Wilcox of the Chain-Belt Co., and E. J. Schuerman of the Jaeger Machine Co.

Factors controlling the riding qualities of a concrete pavement were described by R. B. Gage, New Jersey. David Noonan, New York, discussed methods of patching concrete roads with concrete. Installation of permanent markers on highways was described by H. E. Breed, consulting engineer, New York City. The annual report of the Syracuse test road also was presented by Mr. Breed. The registration of 625 at the convention closely approached the maximum registration at any of the association's nine conventions. Road materials and equipment were exhibited by 23 firms.

Toll Bridge at Kansas City Gets R.F.C. Loan

A LOAN of $600,000 for the construction of a toll bridge over the Missouri River at Kansas City was approved by the Reconstruction Finance Corporation on Feb. 17. The R.F.C. agreed to purchase bonds of the Regional Bridge Company, Kansas City, Mo., which proposes to build the structure. The estimated cost of the bridge is $745,000. Conditions written into the agreement for the proposed loan call for the widening of 7th Ave. in Kansas City and other highway changes.

Other loans approved

The Reconstruction Finance Corp., on Feb. 15, agreed to purchase $100,000 of revenue bonds of the city of Mount Carmel, Ill., to net about $96,000 to finance construction of improvements to the city's waterworks system, including a new raw water intake from the Wabash River and electrically operated pumps. A loan of $19,000 to the town of Ball Ground, Cherokee County, Ga., to finance the construction of a complete new water supply system also was authorized. The announcement states that the R.F.C. agreed to purchase $19,000 of 6 per cent general obligation bonds at par, the bonds to be secured as to principal and interest by the "full faith and credit of the town."

Pending projects advanced

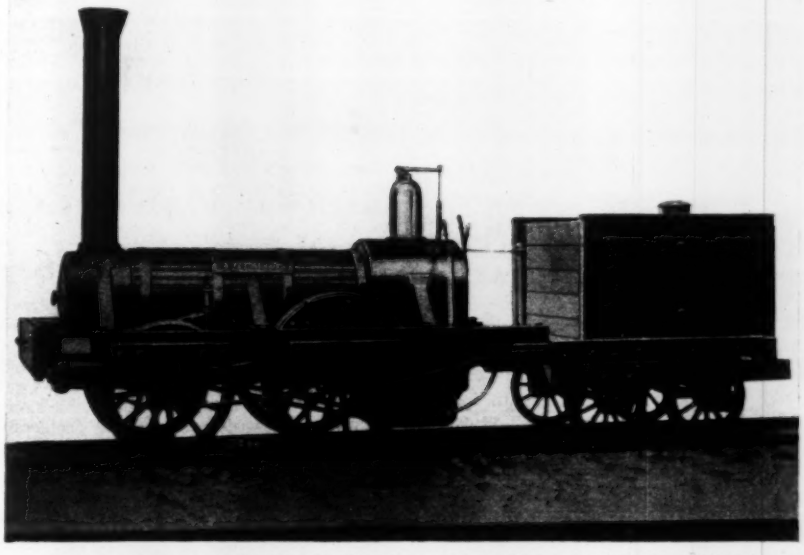
To facilitate start of work on the Grand Island bridges over the Niagara River near Buffalo, as proposed by the Niagara Frontier Bridge Commission, a bill has been introduced into the House of Representatives in Washington to authorize construction of the bridges. A similar bill is to be introduced in the Senate.

Court action to restrain the Louisiana State University from negotiating a loan of $1,250,000 from the Reconstruction Finance Corp., noted last week, has been thrown out by the state supreme court. Following the court's decision Governor Allen announced that negotiations would be started immediately.

Construction of a levee at a cost of $1,000,000 at Indianapolis, Ind., is proposed by the chairman of the city relief organization. An R.F.C. loan is to be asked.

Salem, Ore., is seeking a loan of $75,000 for the construction of a combined truck and water terminal to be leased to the Salem Navigation Co.

McCrory, Ark., has applied to the R.F.C. for a loan of $125,000 for construction of a city waterworks and sewerage system.



MODEL OF OLD IRONSIDES PRESENTED TO FRANKLIN INSTITUTE MUSEUM

Upon the 100th anniversary of an award setting forth the amount to be paid to Mathias W. Baldwin of Philadelphia for the construction of "Old Ironsides," the Baldwin Locomotive Works presented to the Franklin Institute Museum in Philadelphia its treasured scale model of the original locomotive built by the founder of that organization.

In the years 1829-30, because of the interest then aroused as to the possibilities of railroads, Franklin Peale, proprietor of the Philadelphia Museum, applied to Mathias W. Baldwin to construct a miniature locomotive for exhibition. On April 25, 1831, the locomotive with two small cars was put in operation on a circular track at the museum. It used both anthracite coal and pine-knots for fuel, discharging exhaust steam up the stack.

The model proved such a success that the Philadelphia, Germantown and Norristown Railroad placed an order with Mr. Baldwin for a locomotive to operate on its lines in Germantown. The price was to have been $4,000 but the company claimed that the engine did not come up to specifications and an arbitration board awarded Mr. Baldwin a payment of $3,600. Settlement of the claim encouraged him to continue building locomotives, an operation that ultimately expaned into the present great plant of the Baldwin Locomotive Works.

The original locomotive was destroyed in a landslide but the Baldwin Locomotive Works has for years had as one of its cherished possessions the scale model which it now has presented to the Franklin Institute Museum.

Sewage Patent Valid Says District Court In Milwaukee Case

AS REPORTED briefly in these columns last week, Judge F. A. Geiger, of the United States District Court in Milwaukee, on Feb. 7 held that the sewage-treatment patents owned by Activated Sludge, Inc., were valid and had been infringed by the city of Milwaukee. The court in a 70-page decision rejected the claim of the defense that the patents were invalid because independent and earlier invention should be ascribed to Harry W. Clark at the Lawrence Experiment Station and to Harrison P. Eddy at Worcester, Mass. Milwaukee's activated-sludge sewage plant was put into operation in 1925, well within the life of the patents. The case has still to be heard in a court of claims for the assessment of judgment. The city intends to appeal the case to the Circuit Court of Appeal.

Four patents in question

The patents in suit were four, issued to Walter Jones, now deceased, of Jones and Attwood, Ltd., of Stourbridge, England. The effective filing dates were held by the court to be those of the filings of the corresponding British patents, 1913 and 1914. American patents were granted, two in 1917, one in 1918 and one in 1921. The claims of the earliest patent, filed in England on October 11, 1913, cover the process of aerating sewage by introducing air through porous bodies in the bottom of a tank in such a way as to cause circulation of the sewage. The second patent covers the apparatus for accomplishing such aeration. The introduction of sludge into the sewage during aeration and re-aeration of the sludge are covered by the claims of the third and fourth patents.

Much of the testimony in the case related to the history of the development of the activated-sludge process. In great detail evidence was given regarding the work done by Clark, in Massachusetts, and by Fowler, Mumford, Coombs, Ardern and Lockett, and Jones, in England. Clark's work, done in 1912, involving the aeration of sewage in the presence of organisms which were cultivated on slates fixed in a tank, was held not to include the distinctive activated-sludge principle, the circulation of sludge particles through the sewage during the aeration process.

Process developed in England

The opinion recites that shortly after Dr. Gilbert J. Fowler, professor of biochemistry at the University of Manchester, had visited this country and visited the Lawrence Experiment Station late in 1912 he became associated with Jones and set to work to develop a process by which aerobic purification of sewage could be practiced. The experiments led to the adoption of a method involving the circulation of sludge particles bearing aerobic bacteria throughout the sewage. The court held that the English development work showed a clear conception of the distinctive features of the activated-sludge process, while that done by Clark did not.

Experimental work on sewage treatment was begun in Milwaukee in 1914. By the end of 1917 is was decided that the activated-sludge process was best adapted to the city's needs but the demonstration plant was continued in operation until the end of 1919 when the process was formally adopted. The plant was put into operation in 1925.

The trial occupied several weeks in May, 1929, but the case was held under advisement until now.

A similar action was brought against the Sanitary District of Chicago some years ago. Before the case was completed, however, a continuance was granted which has been extended from time to time. The case is scheduled to be resumed on April 3.

Engineering Foundation Gives Aid to Many Forms of Research

The several types of research work aided by the Engineering Foundation, New York, are outlined in the annual report of the foundation for the year 1932. Subjects of special interest to the civil engineering profession are the arch dam investigation and the steel column test work, both of which investigations were completed recently. Other studies include one on the plastic flow of concrete under pressure in large bridges, dams and other structures.

Two summer schools for teachers of engineering received aid from the foundation last year, and recently it agreed to take part in the work of giving courses in advanced engineering for disengaged engineers.

The following have been elected members of the Engineering Foundation Board: John V. N. Dorr, president, the Dorr Co., New York; Harold V. Coes, Ford, Bacon & Davis, New York; Arthur S. Tuttle, consulting engineer, Board of Estimates, New York City.

Liberalization of Relief Act Passed by the U. S. Senate

The Wagner Bill amending the Emergency Relief and Construction Act of 193 was passed by the U. S. Senate on Feb. 2 The bill now goes to the House for i approval.

As passed by the Senate the bill corresponds closely to the outline published la week (*ENR*, Feb. 16, p. 233). The fu from which loans can be made to states increased from $300,000,000 to $600,000,0 and $15,000,000 is provided for relief wor for needy transients in work camps. Limitations on loans to states and municipalities are liberalized by substituting the requirement of "needful in the public interest" for the "self-liquidating" requirement in the original act. The "other tha by taxation" limitation also is removed Interest on loans is set at a rate "not exceeding one per cent more than the rate o interest on current U. S. bonds.

Borrowers are authorized to drawn on the R.F.C. funds up to Jan. 23, 1939, thus saving interest charges in large projects.

As passed by the Senate the amendment strikes out the provision in the existing act which precludes loans on projects which receive support from tax revenues. The R.F.C. is to regard as eligible for purchase debentures issued by any state or commission or other state agency secured by the pledge of receipts from taxes derived from the sale of gasoline, provided the money is devoted exclusively to the improvement of highways.

Funds loaned for relief needs may be expended for the improvement of highways as a part of work relief but the expenditures must be made under the supervision of the state highway department.

Highway Problems Considered by Ohio Engineering Society

PRESENT-DAY highway problems were the principal subject of a three-day meeting of the Ohio Engineering Society held in Columbus Feb. 7-9. At the opening session Governor George White outlined to the 300 engineers assembled for the meeting some of the general problems confronting state officials and O. W. Merrell, highway director, pointed out the relationship between highway work and unemployment relief. Mr. Merrell was followed by L. A. Boulay, former director, who emphasized the dangers involved in diverting money from the highway funds, money which now is used to give employment to thousands of men.

Group meetings held on the second day were well attended and served as round table for the subjects of interest to the various groups. The municipal and sanitary group meeting discussed methods of long time planning and financing necessary public improvements, either by service charges or by general revenue.

The bridge group adopted a bridge loading report which was submitted by a committee on this subject. The group also discussed the use of approach slabs for bridges, suitable filling material for spandrel filled arches, the progress in arc welding, expansion joints for bridges and design of bridges to meet high water conditions. opportunity for county surveyors, state

The highway construction group outlined the importance of salvaging existing pavements, building in safety features such as shallow ditches and non-skid surfaces in highway construction.

The highway maintenance group gave an opportunity for county surveyors, state engineers, and maintenance superintendents to give their ideas of earth road maintenance, traffic bound road maintenance, methods of laying dust, surface treatments, bituminous road-mix surfaces, and the maintenance of all types of pavements. As a satisfactory method of building secondary roads, the general opinion seemed to be that the county should perform or supervise grading and draining and the local subdivisions of the county could then place material on the road as rapidly as needed.

On the third day the program included reports of the officers and a few general discussions including a forceful talk on the duty of engineers in keeping the highway industry on a sound basis at a time when unemployment relief is most essential.

The following were elected officers for the coming year: Fred E. Swineford, president; T. S. Brindle and Vic C. Smith, vice-presidents.

SOCIETY CALENDAR

AMERICAN CONCRETE INSTITUTE, annual meeting, Chicago, Feb. 21-24.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, annual meeting, Chicago, March 13-15.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Chicago, June 27-30.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Chicago, June 26-30.

AMERICAN WATER WORKS ASSOCIATION, annual meeting, Chicago, June 12-16.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, annual meeting, Chicago, June 27-30.

ENGINEERS WEEK, Century of Progress Exposition, Chicago, June 25-30.

FLORIDA SECTION, American Water Works Association, will hold its regular short school at the University of Florida, Gainesville, April 10-12.

COLORADO ASSOCIATION OF HIGHWAY CONTRACTORS has been organized with Platt Rogers of Pueblo as president, A. R. Mackey, Denver, vice-president, and James B. Kenney of Denver as secretary-treasurer. All contractors eligible to bid on state highway work are eligible for membership.

FOURTH ANNUAL GREATER NEW YORK SAFETY CONFERENCE sponsored by the Metropolitan Chapter, American Society of Safety Engineers and the Engineering Section of the National Safety Council is to be held in New York City March 1-2 at the Pennsylvania Hotel.

MILWAUKEE CHAPTER, Associated General Contractors of America, has elected the following officers: President, Frank R. Bell; vice-president, John Steigerwald of Edward Steigerwald & Sons, Inc.; treasurer, Harry L. Foster of the Foster Construction Co.; and secretary, E. D. Steinhagen. Stanley H. Eigel is manager of the chapter.

METROPOLITAN SECTION, American Society of Civil Engineers, at its meeting held Feb. 15 considered the subject of the future of electrical energy distribution. Speakers were Mr. Charles W. Stone, consulting engineer, General Electric Co., who outlined research work now in progress which may result in the wide substitution of direct current for alternating current; Alfred N. Goldsmith, who discussed the unsolved physical problem involved in radio transmission of electrical energy for commercial use; and George A. Orrok and A. H. Kehoe, who outlined the distribution and generating problems of large metropolitan districts.

Personal

CHARLES A. MAGUIRE has been appointed commissioner of public works, Providence, R. I., to succeed FRANK E. WATERMAN. Mr. Maguire is a graduate of the Massachusetts Institute of Technology.

WALTER F. WIRTH, formerly with R. W. Hebard & Co. and With Rene Keilhauer on construction work in Central America, has entered private practice as an engineer at San Salvador, El Salvador, Central America.

MARK BEEMAN, secretary of the Concrete Reinforcing Steel Institute, has resigned from that position to accept the managership of the Washington, D. C. office of the Portland Cement Association. R. W. JOHNSON has been appointed temporary secretary of the Institute to fill the vacancy created by Mr. Beeman's resignation.

L. H. ROBINSON, formerly assistant engineer of maintenance, Canadian National Railways, Atlantic Region, has been appointed division engineer at Halifax, N. S., and the position of assistant engineer of maintenance has been done away with as an economy measure.

ALEXANDER MCLELLAN, Little Rock, Ark., has been appointed supervisor of maintenance, Arkansas State Highway Commission. Mr. McLellan came to Arkansas about five years ago as representative of Warren Bros. on highway work and more recently has been with the Hogan Construction Co.

W. MCLEAN BINGLEY has been appointed assistant sanitary engineer of the Chlorine Institute, New York. Mr. Bingley is a graduate of Johns Hopkins University and formerly was with The Dorr Co. Mr. Bingley will be assistant to L. H. ENSLOW, sanitary engineer of the Institute in charge of its work in connection with the chlorination of sewage and industrial waste.

JAMES H. RHYNE has been appointed to the newly created position of director of highways, Arkansas State Highway Commission. Mr. Rhyne is a graduate of the University of Arkansas in civil engineering and for the past 25 years has been engaged in general engineering and contracting work in Arkansas, Missouri, and Louisiana. He is president of the state board of registration for professional engineers and a past president of the National Council of State Boards of Engineering Examiners.

Obituary

CYRIL E. MARSHALL, consulting engineer to the towns of Valley Stream, Hempstead, Cedarhurst, Woodbury, Farmingdale and Floral Park, Long Island, died at Garden City, L. I., on Feb. 16, age 54 years.

EDGAR G. BARRATT, former president of the Union Bag & Paper Co. and consulting engineer at New York, died in New York on Feb. 16, age 69 years. Mr. Barratt was a graduate from the engineering department of Columbia University.

JAMES H. JOWETT, executive vice-president, Ingersoll-Rand Co., died in New York City on Feb. 16 following a long illness. Mr. Jowett entered the employ of the Ingersoll-Sergeant Drill Co. soon after leaving school and has been continuously with that company and its successor, the Ingersoll-Rand Co.

ANDREW J. NEAFIE, principal assistant engineer, Delaware, Lackawanna & Western R.R., died at his home in Mountain Lake, N. J., on Feb. 11. Mr. Neafie entered the service of the Lackawanna Railroad in 1880 in the engineering department and had served as roadmaster and general roadmaster before his appointment as principal assistant engineer.

WALTER H. RICHARDS, retired superintendent of the water and sewer department, New London, Conn., died at his home there on Feb. 17, age 81 years. Mr. Richards began his service with New London as an engineer on the construction of its water supply system and later became superintendent of the water department, a position which he held for more than 45 years. He retired from active service in 1921.

Contract for San Gabriel Dam Upheld by Los Angeles Court

Legality of the West Slope Construction Company's contract with Los Angeles county board of supervisors to build the San Gabriel Dam No. 1 was upheld Feb. 15 in a judgment of the Los Angeles, Calif., county superior court. The decision was given in the suit brought by Jacob J. Lieberman, attorney, suing as a taxpayer, against the county and the firm to enjoin the work under contract. The suit set forth a number of asserted irregularities attending the letting of the contract, including that the terms of the contract were uncertain and that the county had no clear title to the dam site.

Railroad Problems Outlined in Transportation Report

(Concluded from p. 262)

holding companies nor any other device should be permitted to hinder consolidation or evade the letter or the spirit of regulatory law.

(2) Unprofitable railroad service should be replaced by cheaper alternative transport methods.

(3) Railroads should be permitted to own and operate competing services, including water lines, but regulatory jurisdiction should be extended to water rates and practices in coastal, intercoastal and lake shipping to relieve commerce of present chaotic conditions. Congress should promptly clarify its intention on the long-and-short-haul clause of the transportation act.

(4) Government assumption of all or part of the costs of inefficient competing transport as a defense against monopoly is no longer warranted and should be abandoned. As a general principle inland waterways should bear all costs of amortization, interest, maintenance and operation of the facilities for their navigation. If they cannot bear such charges and compete with other forms of transport, they should be abandoned. The St. Lawrence Waterway should be tested by this rule of self-support and if it fails in that test the pending treaty with Canada should not be ratified. Governmental commercial operation of the actual facilities of transportation, such as barge lines, should not be continued.

Handicapping disapproved

(5) Automotive transportation should be put under such regulation as is necessary for public protection. It should bear its fair burden of tax but only on a basis of compensation for public expenditure on its behalf, plus its share of the general tax load. Neither tax nor regulation should be applied for any purpose of handicapping the march of progress for the benefit of the railroads.

(6) Wages and working conditions of labor in transportation are determinable by established procedure in another forum and are not within the scope of this inquiry. There should be no heavier burdens on the railroads in employing labor to

operate automobiles than on their competitors. In the railroads (as in other industries) rates, capitalization, salaries and wages must all follow changing economic conditions, but none should be sacrificed for the benefit of others.

(7) Beacons, weather service and similar auxiliaries to air traffic should be maintained at public expense, and air transport should be encouraged during its development stage, but we believe that every such service should ultimately pay its own way.

(8) The committee has no recommendation to make on pipe lines.

Rate base change proposed

II. The policy of trying to appraise railroad properties on some selected basis of valuation and then saying that they are entitled to earn a fair return on this appraisal should be reconsidered. Where competition with trucks and other methods exists, it will determine rates. In other cases, rates must be regulated, but the basis of costs of operation under efficient management is a better general guide than any attempt to preserve capital structures regardless of economic trends. We see no reason why the rate-making rule should not say in plain English that railroads are entitled to make a reasonable profit based upon costs of efficient operation and that they are not entitled to earnings merely to preserve present structures if overcapitalized.

Internal railroad problems

III. The railroads should do much that they have not done to improve their condition without any government help at all. They should promptly be freed of all unnecessary restrictions on the doing of it. It has been estimated that less than a 20 per cent increase in traffic would put most of them on an earning basis. In view of the narrowness of this margin of loss and of the very great savings possible in railroad operation, we regard their outlook as far from hopeless.

(a) Railroads should adopt the competing methods of which they complain.

(b) Railroads should cooperate to reduce competitive expense.

(1) Unnecessary services should be abandoned.

(2) Metropolitan terminals should be consolidated and unnecessary facilities scrapped.

(3) Circuitous haulage should be eliminated.

(c) Financial management should be improved.

(d) Transport methods and equipment should be brought up-to-date.

(e) In view of what could be done by better management, the general outlook seems far from hopeless.

IV. Regulatory jurisdiction should be extended to the whole national transportation system but applied only to the extent necessary for public protection. The existing regulatory mechanism of the Interstate Commerce Commission is inadequate and should be improved by reorganization without expansion or increased expense.

Emergency recommendations

(1) Corporate reorganization can and should be facilitated by revision of the bankruptcy procedure.

(2) The recapture clause should be repealed retroactively.

(3) The statutory rule of rate-making should be revised.

(4) "Adequate security" does not necessarily mean "marketable collateral."

Contracts and Capital

CONSTRUCTION

(Thousands of Dollars)

	Weekly Average Four Weeks Feb., 1932	Week Feb. 23, 1933
Federal government	$1,869	$3,738	$2,641
State and municipal	9,721	5,873	6,019
Total public	$11,590	$9,611	$8,660
Total private	9,863	5,517	7,351
Week's total	$21,453	$15,128	$16,011
Cumulative to date:			
1932		$179,395	
1933		155,905	

NEW PRODUCTIVE CAPITAL

(Thousands of Dollars)

	Weekly Average Four Weeks Feb., 1932	Week Feb. 18, 1933
R.F.C. loans made	.....	.....	.....
New capital issues	$15,750	$7,500	$2,600
Total	$15,750	$7,500	$2,600
Cumulative to date:			
1932		$147,250	
1933		54,600	
R.F.C. self-liquidating loans:			
Approved current week			$719
Approved to date (including 1932)			$172,925
Actual loans made (including 1932)			17,753

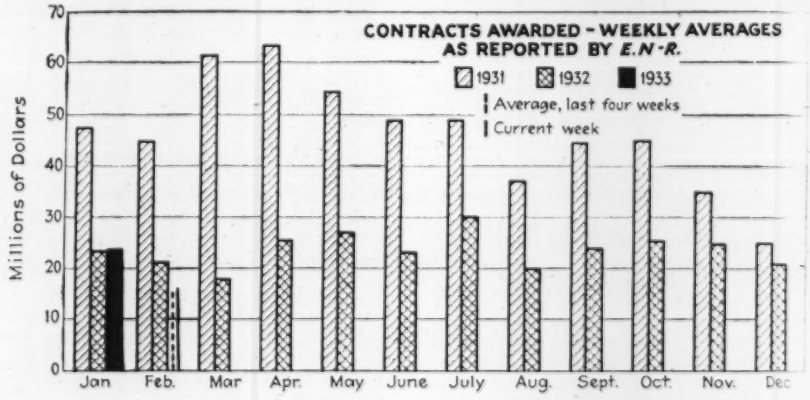
ENR Cost and Volume Index

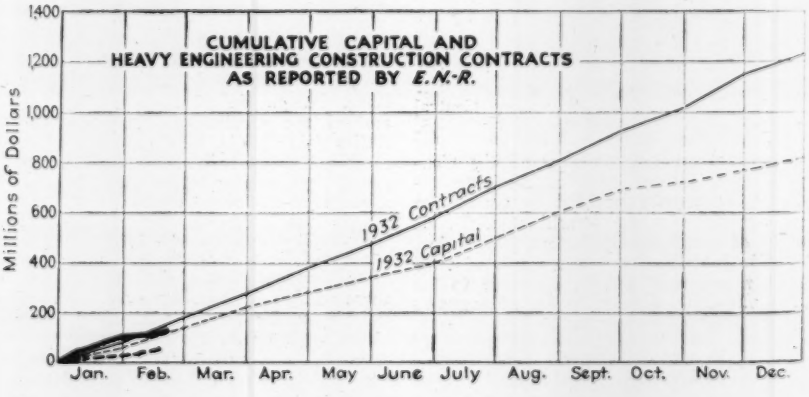
E.N.-R. Cost		E.N.-R. Volume	
February, 1933	**159.30**	**January, 1933**	**129**
January, 1933	158.44	December, 1932	113
February, 1932	161.82	January, 1932	121
1932 (Average)	156.97	1932 (Average)	127
1931 (Average)	181.35	1931 (Average)	220
1930 (Average)	202.35	1930 (Average)	260
1913 Average	100		

Engineering Contracts and Capital

HEAVY ENGINEERING construction contracts reported for the past week total $16,011,000, a considerable increase over the previous week's total of $9,464,000. The current week's reports are one day short on account of closing these pages early to meet a holiday printing schedule. Of last week's total, nearly half, or $7,351,000 represents private contracts. This is the second consecutive week that private lettings have exceeded 7 millions. Public works contracts for the past week totaled $8,660,000, more than four times those of the previous week. Federal awards more than doubled, amounting to $2,641,000. Highway lettings showed a strong comeback from $600,000 for the previous week to $3,900,000 for the past week. The past week's total of 16 millions exceeds the four-week average total of $15,128,000. Last year contracts averaged $21,453,000 during February. Large single contracts reported last week include apartments, New York City, 3 millions, and highways, Texas, $1,400,000.

New capital issues, all public, reported last week were unusually low, amounting to only $2,600,000. Of this amount nearly 2 millions was for public works in Columbus, Ohio.



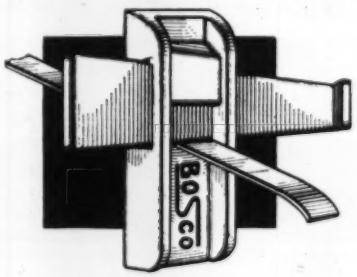


Construction Equipment and Materials

Clamp for Concrete Forms

A new form clamp to lock band iron form ties in place before and during pouring operations is announced by Bosco Form Service. The clamp is of two piece design, consisting of a malleable cast body and a wedge. The latter passes through a slot in the body of the clamp and is so designed as to be inseparable from it.

In operation the form clamp is placed against the form, the band iron form tie being passed through an opening in the center of the clamp. After the form box



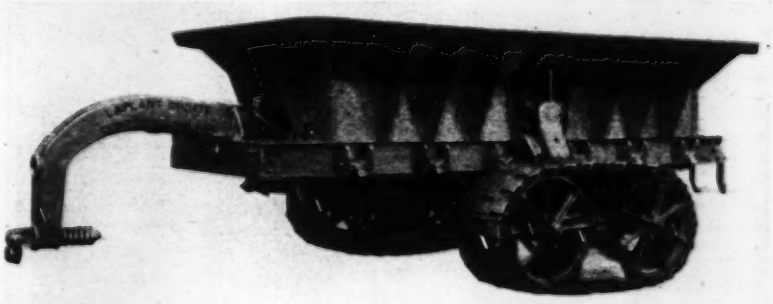
Bosco form clamp comprises a malleable cast body and wedge

has been drawn into position with a tightening tool the wedge is struck with a hammer driving it in place against the band iron form tie and against the upper edge of the slot. The latter is designed with a shoulder that crimps the band iron and provides a lock to hold it from slipping. After concrete has been poured the form clamp is easily released by loosening the wedge with a hammer, upon which the form clamp is readily withdrawn from the tie. The chief advantages of this new clamp lie in the ease and speed of application.

New 12-Yd. Dump Wagon

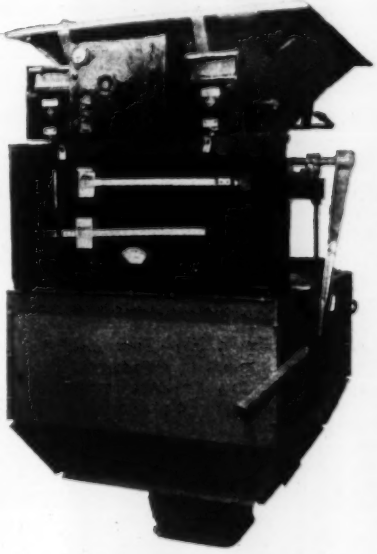
The La Plante-Choate Manufacturing Co., Inc., of Cedar Rapids, Iowa, announces the manufacture of a new, bottom dump "Roadlayer" wagon that will haul a 12-yard heaped capacity load. Departing from the conventional "sloping-side" wagon, which is in predominant use by earth-moving contractors, this wagon has been built with straight wagon body sides, permitting easier and quicker dumping in all kinds of soil. The extra-wide doors and high clearance permit the wagon to be quickly and easily dumped and hauled off the windrow, with very little increase in draft. When the doors drop the draft immediately lightens so that it is not necessary to shift gear while on the dump. The wide flange provided at the top of the wagon box is designed to carry a large top load, and has proven to be particularly advantageous when loading with dragline, shovel or elevating grader.

Laplante-Choate "Roadlayer"



Cement Weighing Batcher Fully Automatic

The Blaw-Knox Co., Pittsburgh, Pa., has placed on the market a full automatic cement weighing batcher for concrete mixing plants, electrically operated, in a complete range of sizes. The batcher can be equipped either with beam scales or with springless dial scales, as desired. Electrical



Electrically operated cement weighing batcher by Blaw Knox

contracts are included with the scale equipment for automatic operation.

The feeder unit which is attached to the storage bin consists of a cylindrical rotor with a series of pockets on its circumference. This rotor revolves and takes the cement from the storage bin, dumping it into the cement weighing hopper. Power is furnished by means of a totally inclosed electric motor with reduction gear built in. The feeding mechanism is started by a push button and when the required number of pounds of cement have been deposited in the weighing hopper the feed is automatically cut off.

New Publications

Piping. Air Reduction Sales Co., Lincoln Building, New York, N. Y., has issued a 26-page booklet entitled "Piping Tailored to Fit" which reviews the advantages of oxyacetylene welding in the piping field and discusses in detail the economies achieved when piping is fabricated by this method.

Vibrating Screens. Link-Belt Co., Philadelphia, Pa., has recently completed a new illustrated catalog, No. 1362, giving sizes and types of vibrating screens available, with dimensions, descriptive matter and installation views. Both unbalanced-pulley drive and heavy-duty positive drive type screens are covered.

Synchronous Motors. The Ideal Electric & Manufacturing Company, Mansfield, Ohio, announce their Bulletin 540, giving a full description of the "Self-Syn" Motor. The bulletin consists of 20 pages and contains complete details of the design, construction and characteristics with illustrations, diagrams, and characteristic curves.

Rubber Goods. Containing engineering information and data never before published, a new condensed catalog of industrial rubber goods has been issued by the B. F. Goodrich Rubber Co., Akron, Ohio. It is titled "Engineering Data, Industrial Rubber Goods." It includes engineering data on rubber transmission belting, conveyor belts and rubber hose.

Liner Plates. The Truscon Steel Co., Youngstown, Ohio, has issued Data Book No. 5, a 24-page booklet containing engineering data, formulas for determining the proper thickness of metal to be used under various conditions, properties of three standard types of Truscon steel liner plates and illustrations of their use in construction.

Sheet Piling. A 30-page insert to be included in its publication "Carnegie Steel Sheet Piling" has been published by the Carnegie Steel Co., Pittsburgh, Pa. It comprises condensed translations of the work published in 1931 by Dr. H. Blum on the methods of determining bending moments and of that published in 1926 by Dr. H. Krey on earth pressures.

Steel Grid Floors. A 10-page illustrated booklet has been published by the Truscon Steel Co., Youngstown, Ohio, describing the Truscon Plategrid and Floorgrid types of flooring. Plategrid is an all-steel grating for use as open-type flooring. Floorgrid consists of steel units embedded in concrete or mastic filling and makes a durable wearing surface for heavy duty floors.

Gas-Electric Sets. "Gas-Electric Sets for Every Application" is the title of an illustrated 8-page publication recently issued by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. The sets are designed for furnishing continuous or auxiliary power supply for construction camps, barges, dredges, excavation operations, wharves, docks, loading platforms, lumber camps, quarries, etc. They are also suitable for all kinds of emergency service.

Steel. A new issue of the Ryerson Journal and Stock List has just been published. In addition to complete general descriptions, specifications, sizes, etc., it contains the new extras on bands, the new cold finished steel extras, the new hot rolled cutting extras, and other information of value to the steel user. The address of the company is Joseph T. Ryerson & Son, Inc., Chicago, 16th and Rockwell Sts., Chicago, Ill.

Auger. A new bulletin which illustrates and describes a method of boring in place of open trench digging has been published by the Hydrauger Corp., 233 Broadway, New York, N. Y. This bulletin shows in graphic form the Hydrauger method of mechanically boring under pavements, railroad tracks and other obstructions. It illus-

trates by use of graphs the cost of boring different distances in different diameters and also shows the speeds and degree of accuracy with which bores can be made.

Concrete Proportioning. A 24-page booklet has been issued by the Toledo Scale Co., Toledo, Ohio, describing the Toledo method of proportioning concrete by weight. The special weighing apparatus manufactured by the company for use in aggregate proportioning is described in detail, including a specially equipped unit for making automatic compensation for moisture, a scale provided with a photo electric cell cutoff device, and a graphic recording attachment for concrete batching.

Belt Conveyor. A handbook for designers of material-handling equipment, designated at Bulletin No. 82, has been published by the Robins Conveying Belt Co., New York, N. Y. The book consists of 100 pages and contains tables and charts for determining the capacity, speed, width, power and belt-ply of any belt conveyor. The tabulated data are in an unusually convenient form. There are numerous pictures from photographs of installations showing the application of belt conveyors to a variety of industries.

Concrete Pipe Culverts. A 24-page illustrated booklet published by the American Concrete Pipe Association, Chicago, Ill., describes the use of reinforced concrete pipe for culverts. The booklet describes the observations made by two engineers who examined 186 reinforced concrete pipe culverts in Pennsylvania, New Jersey, Delaware, Maryland, Washington and British Columbia in 1931. Modern methods of constructing concrete pipe culverts in open cuts, in tunnels and by jacking through fills are also described.

Bulk Cement Handling. A new catalog has been published describing the portable Fuller-Kinyon system for handling bulk cement. The booklet is particularly intended to illustrate simplified mixing and batching plant design with reference to the unloading, handling and storage of both cement and aggregates. It covers central mixing plants, general construction and highway contractors' plants and floating mixing plants. Various methods of unloading railroad cars and barges are shown, together with the use of the same system for conveying cement to and from warehouse storage. It is published by the Fuller Co., Catasauqua, Penna.

Strain Gauges. A new 12-page bulletin, No. 37, has been issued by Baldwin-Southwark Corp., Philadelphia, Pa., covering the line of lever-type strain gauges known as Huggenberger Tensometers. A short technical discussion of the fundamental principles of these instruments is followed by detail data and suggestions concerning application of the various types of tensometers. Fixing devices which are necessary in the application are fully described and illustrated. A section describing the methods of mounting and using tensometers and fixing devices concludes the booklet. The Huggenberger tensometer is a multiplying lever device for measuring the strain in a specimen under load.

Arc Welding. "The Novice Understands and the Expert Appreciates" is the title of a bulletin recently published by the Harnischfeger Corp. of Milwaukee, describing in detail the construction and operating advantages of the P & H-Hansen arc welder, now manufactured by the Harnischfeger Corp. The bulletin includes a description of a so-called "internal stabilizer." The advantage claimed for the new type of stabilizer is the elimination of weight and extra equipment plus the assurance of a more uniform flow of current and a consequent increase in the efficiency of the arc. Other features of the P&H-Hansen arc welder include provision for the elimination of the exciter and a simple and effective single control for gradations in the welding current.

Business Notes

THOMAS ELEVATOR CO., 20 So. Hoyne Ave., Chicago, Ill., announces that it has changed its name to Thomas Hoist Co. There has been no change in ownership, management or personnel. The business of the company is the manufacture of electric, steam and gasoline hoists.

ORGANIZATION OF THE CALCIUM CHLORIDE ASSOCIATION with offices at 4200 Penobscot Building, Detroit, Mich., has been announced. Members include the Solvay Sales Corp., the Dow Chemical Co., the Michigan Alkali Co. and the Columbia Alkali Corp. Ray A. Giddings has been appointed secretary.

New Line of Meters For Sewage and Water Plants

A complete line of meters for sewage treatment plants and waterworks has been announced by the Bailey Meter Co., Cleveland, Ohio. The accompanying illustration shows the float-operated register for measuring the flow of sewage, sludge, dirty water or other liquids using a Venturi tube, flow nozzle or orifice as the primary element. The instruments indicate, integrate and record flow, charts being 12 in. in diameter with uniform graduations. The maximum capacity of the register can be changed by changing two sets of gears in its mechanism. The pressed steel casing is designed for either flush front or surface mounting.

Float-operated register for flow meters

New Equipment in Brief

Electric Welder. The new P&H Hansen gasoline driven arc welder has been announced by the Harnischfeger Corporation, Milwaukee, Wis. It has a capacity of 300 amp. and is driven by a 42 hp. gasoline motor.

Rock Explosives. Apex No. 1, a new rock explosive, is announced by the Atlas Powder Co., Wilmington, Del. It is a high explosive of the low-density type, provided for quarry blasting. It generates a force of low violence as regards shattering action but of sufficient power to destroy the crystalline nature of rock.

Magnetic Clutch. Flow instruments which transmit the motion of an internal float to the recording pen or indicating hand by means of a magnetic clutch have been announced by the C. J. Tagliabue Manufacturing Co., Brooklyn, N. Y. The magnetic clutch eliminates the conventional pressure-type bearing.

Aluminum Vise. The Columbian Vise & Manufacturing Co., Cleveland, Ohio, announces a light aluminum-alloy machinist's vise with 3-in. jaws, weighing 12 lb. Aluminum castings are used for the front and back jaws and for the swivel base. Jaw faces are of heat-treated tool steel and a screw and handle are of cold-rolled steel.

Crawler Shovel. The Universal Crane Co., Lorain, Ohio, announces a new line of crawler-shovel and crane equipment ranging from ¾ to ⅞ yd., known as the Lorain 40 and 30. The working weight of the Lorain 40 as a ¾-yd. shovel is 30,000 lb. and of the Lorain 30 as a ½-yd. shovel, 23,000 lb. The machinery frame is tilted toward the rear, allowing the turntable machinery weight to counterbalance the load.

Automatic Check Valve. The Chapman Valve Manufacturing Co., Indian Orchard, Mass., has placed on the market a full-way check and stop valve of the cone type. It is designed to cause minimum loss of head and embodies a quick-closing feature, minimizing water hammer. The plug has inserted bronze rings, machined to accurate finish so as to contact in the body only on the bearing surface of the bronze seat ring. In order to secure proper alignment of the plug in the body, the plug is carried on bronze lined trunnions. The spindle is of forged stainless steel and is secured to the plug by fitted studs. In operation the plug is first raised vertically off the seat without rotation, so that the plug is entirely free from the seats before the rotating operation for opening is started. The valve is then rotated to any desired position by the operating mechanism. Raising and rotation of the plug are accomplished by one continuous movement.

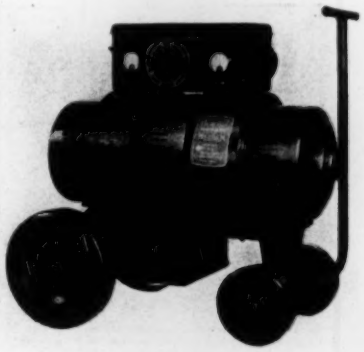
Light-Weight Rock Drill

The Gardner-Denver Co., Quincy, Ill., announce a new lightweight all-purpose drifting drill in the 2½ in. cylinder class, suitable for mines and quarries. The separate cylinder bushing has been eliminated and a renewable bronze liner pressed into the cylinder supporting the front end of the hammer. This liner also serves as the inner wall of the integral

New drifting drill by Gardner-Denver

lubricator, through which the lubricant is fed to the rear end of the chamber. The machine is also designed so that a line oiler may be used for lubrication if preferred. The drill rides low in the shell and the absence of protuberances permits drilling close to the wall or back, where holes at extreme angles are needed.

High-Capacity Electric Welder

A newly designed electric welder is announced by Hobart Bros. Co., Troy, Ohio. The manufacturer states that it has 60 per cent more capacity than previous models and is fitted for handling both coated rods with their 42-volt requirements and 25-volt plain rods. Its construction renders it proof again rain. It also is equipped with remote control that allows the operator to control the welding current while some distance away from the machine.

New electric welder by Hobart Bros.